ALTERNATIVE STORMWATER MANAGEMENT IN A NEW URBANIST COMMUNITY

by

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(Under the Direction of Bruce K. Ferguson)

ABSTRACT

New urbanism creates relatively dense, impervious development and has been shown to incur greater environmental impacts than comparable development types, particularly in regard to water quality. This thesis examines a case study new urbanist development. An alternative landscape design is proposed that seeks to implement ecologically-sound stormwater management practices within the prescribed layout of the development's buildings and streets.

INDEX WORDS: Alternative Stormwater Management, New Urbanist Communities

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I dedicate this effort to my wife, Debbie. This has been such a special adventure; thank you for your love and support.

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CHAPTER 1: INTRODUCTION

In recent past, the management of stormwater has become an increasingly important objective in developing regions around the world. As growing populations build homes, businesses and roads over what was previously forests, fields and wetlands, increasing volumes of stormwater runoff are generated with the occurrence of rain. This is due primarily to the fact that these buildings and roads are constructed of impervious materials; i.e. materials that do not readily infiltrate rainwater. The inordinately high volumes of runoff are responsible for a range of environmental degradation that includes flooding, the erosion of soil, the pollution of waterways, the deprivation of groundwater supplies and the decline of base flow.

It is important that we recognize our successes and failures so that we might take the necessary steps to fix them. Designers should learn from mistakes; this is a fundamental component of good design. Development that is predictably responsible for environmental damage is the direct opposite of good design.

The purpose of this thesis is to examine a specific development type and its inherent ability to manage stormwater; the development type is new urbanism. New urbanist development, also referred to as traditional neighborhood development (TND), has gathered much interest over the past two decades as a popular alternative to suburban sprawl.

New urbanism describes a form of development that has originated and developed in opposition to the homogenous, suburban sprawl that characterized growth and land use throughout the United States in the second half of the twentieth century. New urbanism promotes mixed-use developments in which residential, civic and commercial spaces coexist and support one another. These places are designed to address the needs of the pedestrian as much as they are the automobile.

Unfortunately, these communities of new urban design have been shown to incur greater environmental impacts than comparable development types, particularly in regard to water quality. The typical new urbanist template creates dense, relatively impervious developments. Where storm-water management has been added to new urbanist communities, it has been an afterthought, tacking devices outside the developed areas to fix the problems that the developed areas created. Cynthia Girling and Ronald Kellett analyzed these environmental effects in their article, "Comparing Stormwater Impacts and Costs in Three Neighborhood Types." (Girling and Kellett, 2002).

Girling and Kellett compared the physiology of three development types; a suburban housing development, a conservation subdivision and a development built according to traditional neighborhood (new urbanist) principles (Figure 1-1). These three development patterns

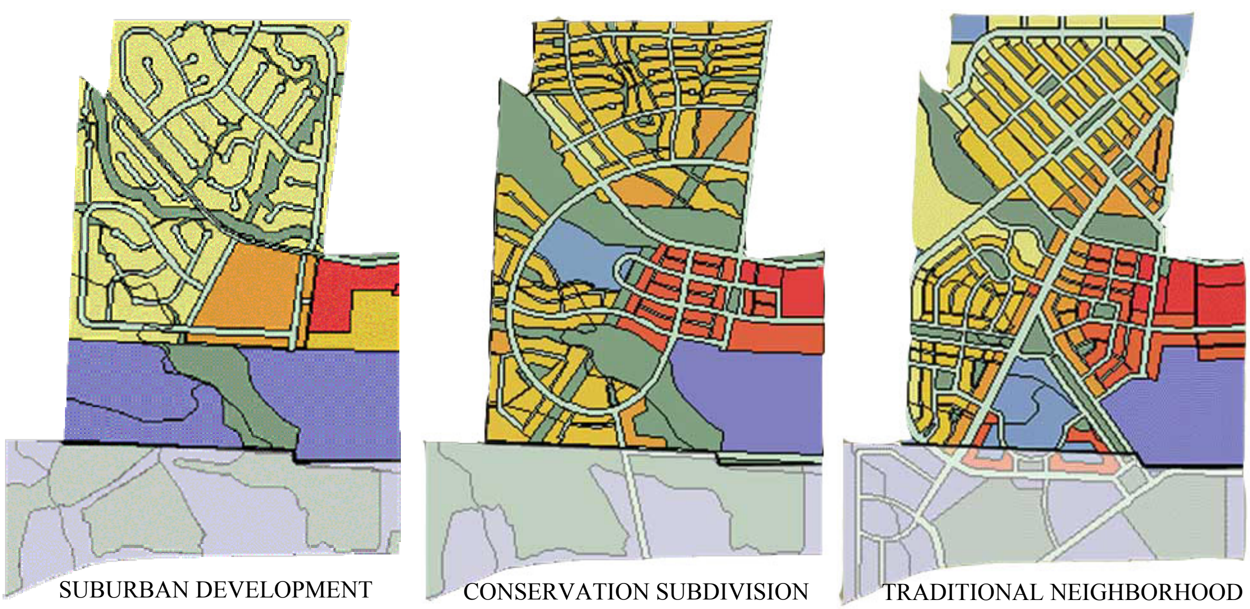


Figure 1-1: Comparison of three development types; Girling & Kellett, 2002.

were analyzed and compared in an effort to gauge their inherent effects upon water quality and stormwater. A development of each type was proposed for the same land parcel, the existing site conditions were identical for all three. A wide array of features was incorporated into each of the three theoretical developments, including residential and commercial areas, civic institutions and open space.

The suburban development was referred to as "Status Quo" because it was composed of typical development patterns found in the United States. Residential zones of this alternative were comprised of low-density single-family lots (averaging 8,000 square feet per lot) and medium-density attached housing. The commercial area of the site was isolated from these residential areas. A primary street possessing a 70' right of way traversed the site. Collector roads routinely branched off from this main thoroughfare to the various portions of the development; many of these secondary roads terminated into cul-de-sacs. Sidewalks and planting strips were typical features of roads. Residential driveways were accessed from the street. Commercial areas provided off-street parking between businesses and roads.

The conservation development plan was referred to as an "Open Space" alternative because it incorporated the existing, pre-developed drainage patterns, topography and vegetation (trees) into its design. Relatively dense, mixed-use development characterized the built portions of this alternative type. Housing options ranged from low- and medium-density single family lots to relatively dense multifamily and mixed-use buildings. Relatively narrow roads, which were laid out so as not to adversely affect existing natural processes, were typically lined with sidewalks and planting strips. Residential garages were accessed via alleyways. A prominently commercial town square served as the development's centerpiece.

The "Neighborhood Village", the third alternative development type offered in the study, was built according to new urbanist principles. Streets, roads and alleys formed a regular grid pattern throughout the built portion of the site. Mixed-use, relatively dense development was arranged in the form of several neighborhoods around a prominent, predominantly commercial urban core. Residential options ranged from single-family lots to multi-family and live/work buildings. Commercial establishments were integrated with residences, offering community members opportunities to access certain daily needs by foot rather than by car.

Girling's analysis and findings provide some important information regarding the physical makeup and environmental effects of the Neighborhood Village alternative in comparison to the other development patterns. More than half of the entire site (54%) was composed of impervious material (other two alternatives were 40% and 42% impervious). The Neighborhood Village incorporated the most extensive roadway system of the three alternatives, allotting 27% of the entire site to street and alleyway pavements. The Neighborhood Village alternative was responsible for the greatest increase in peak flow rates from the site; rates increased 34% for the 10-year storm (vs. 26% for Status Quo and 5% for Open Space alternatives). Even with these high concentrations of impervious surface, overall density of the Neighborhood Village (average of 15 units per acre) was still slightly less than that of the Open Space alternative (average of 16 units per acre). And finally, the Neighborhood Village alternative proved to be the most expensive of the three alternatives, when calculated on a per-dwelling basis.

It is the new urbanist pattern that will serve as the object of scrutiny in this thesis. Following an analysis of the case study in Chapter Four, an alternative landscape design will be proposed in Chapter Five. The design will explore the potential to retain and infiltrate rainfall within the prescribed parameters of the new urbanist model. The given network of buildings and roads will serve as constraints within which the landscape will be altered to function more efficiently. Stormwater management will be an integrative component of the design.

The alternative landscape design's effectiveness in managing stormwater will be evaluated using two indicators. Each of these indicators will be applied to three different scenarios: the pre-developed site, the original new urbanist design built according to conventional building practices, and the alternative post-developed site proposed in Chapter Five. The comparison of these scenarios will lend significant insight to the potential for stormwater management within the typical new urbanist pattern.

The first gauge used to compare the three scenarios will be the percentage of impervious surface. The percentage of impervious surface of a site is directly proportional to the volume of stormwater runoff generated, as was found by Arnold and Gibbons (Arnold and Gibbons, 1996). Arnold and Gibbons argued that impervious surface is the primary factor in determining levels of runoff, non-point source pollution and degraded water quality.

Secondly, there will be a comparison of the Curve Numbers of the pre-developed and post-developed sites. A Curve Number, or CN, is the ratio of the volume of water that leaves a given area as runoff to the total volume of water that falls upon that given area with the occurrence of rain. Two post-developed Curve Numbers will be offered; one calculated for the overall site built according to conventional building methods and materials, the other calculated using the alternative landscape design post-developed site offered in Chapter Five.

This procedure will identify the inherent limitations of Traditional Neighborhood development and the new urbanist model in meeting environmental expectations. It will explore the degree to which new urbanist communities can utilize sound stormwater management practices without altering their physical layout or their fundamental objectives. It is therefore the purpose of this thesis, to examine the physical make up of a typical new urbanist development and to suggest better practices by way of an alternative landscape design.

CHAPTER 2: STORMWATER MANAGEMENT

The focus of this thesis is the stormwater management capabilities of a specific development pattern. In order to fully appreciate what stormwater management is, it is necessary to first review the natural processes that govern the movement, storage and transformation of the earth's water, collectively referred to as the hydrologic cycle.

Condensation of water vapor occurs in the upper atmosphere and is released as precipitation in the form of rain, snow or ice. Some precipitation falls upon the leaves and branches of trees and plants as it first reaches the earth; this is known as interception. In light rain showers, virtually all of the rain that falls upon the canopy of a tree may be intercepted by its leaves without ever reaching the ground. Coniferous plants are especially effective because they maintain canopy throughout the year. In a densely populated woodland with mature canopy over an established understory, a great amount of surface area exists in the form of leaves, stems, branches and trunks. All of these surfaces are potential resting points for tiny water droplets. During the course of a year, between 10 and 35% of the precipitation that falls over a densely-vegetated area will be intercepted by the trees and plants without ever reaching the ground (Swank et al, 1972).

Water that is not intercepted by vegetation falls to the earth, continuing its movement toward a low point. The soil and microenvironment associated with the immediate ground layer determine the specific direction that water will travel. Porous, permeable surfaces allow for the infiltration of water into the soil. Soil is composed of minute particles of sand, clay, organic matter, and various microorganisms. Additionally there is a matrix of voids or pore spaces that exist between and amongst these particles. Water that inhabits these top several feet of soil is referred to as soil moisture. This is the soil region in which plants' fibrous root systems may spread and grow in search of water.

Water absorbed up by plants will eventually be released back into the atmosphere through transpiration. Plants transpire water through tiny openings called stomata on the underside of their leaves. The terms transpiration and evaporation can collectively be referred to as evapotranspiration. This refers to the combined release of water vapor into the air from vegetation, their associated soil and groundlayer, as well as the surrounding environment. Water that is not taken up by plants or bound to soil particles will continue to travel down through the soil, slowly moving through its interstices till it reaches the water table, or ground water.

Although not visible, ground water is a vital component of the hydrologic cycle. Ground water flows laterally through the voids and pores of soil and bedrock deep beneath the earth's surface. Ground water often serves to recharge rivers. Regular ground water supplies allow rivers to maintain relatively normal base flows, supporting the health and well-being of the plant and animal life that inhabit them.

Water that lands upon saturated soil or an impervious surface will also continue to seek a low point as it travels downward across the face of the earth. This is what is commonly referred to as stormwater runoff. The movement of water over the earth's surface can occur in a variety of ways. It may occur as sheet flow, a thin layer of water with no clearly defined channel. Runoff may also take a more concentrated form of flow under certain conditions. Swales or pipes concentrate large volumes of runoff into a specific path. Exposed soils, such as those on construction sites, are subject to concentrated flow erosion as runoff seeks out a low point.

The effect is an eroded channel that will continue to deepen and widen until otherwise stabilized. Stormwater runoff continues its journey downhill, over the earth's surface or collected and piped underground. Runoff that is not evaporated or infiltrated somehow along the way will eventually find its way to a stream or river and will continue on its path toward the ocean. The majority of evaporation occurs from these ocean waters. It is this water vapor that rises to the atmosphere that will once again fall to the earth as precipitation; the water cycle flows on.

Stormwater runoff does occur in pristine, natural environments; i.e. a road or building is not a prerequisite for runoff. It is simply a matter of scale. The development of the last century generated more runoff and allowed less infiltration because it was constructed primarily of impervious materials.

In years past, urban stormwater runoff was collected and piped to nearby rivers and streams. As the harmful effects of such techniques were realized, stormwater management trends shifted to site-specific detention basins. Detention basins reduce peak discharge flows by releasing collected runoff through relatively small outlets. Unfortunately, there are also environmental and aesthetic problems associated with such structures. Collection, conveyance and discharge of water through pipes ignores vital processes of hydrologic cycle such as infiltration, groundwater surcharge and the base flow of waterways. Also, the large volumes of water collected in these detention basins, although released at relatively low rates, are still responsible for increased storm flows of waterways for extended periods of time.

In addition to the environmental consequences of conventional stormwater management techniques, extended detention basins possess inherent aesthetic problems as well. They are often eye sores, relegated to the back corner of a lot in an effort to be inconspicuous. Rarely are they integrated into a site as a functioning participant of the design. They do not provide usable open space but rather, are typically encompassed by a fence. Extended detention basins waste valuable space; their sole purpose is to temporarily accommodate excessive runoff generated by impervious development.

It is the intent of this thesis to institute a definition of stormwater management that progresses beyond pipes and detention; these methods may better be referred to as stormwater diversion and relocation. True "management" of stormwater should incorporate a built environment into a natural one without adversely affecting existing systems such as the hydrologic cycle. Severance of this process at any phase of this sequence should hardly be termed "management." Management techniques applied to the alternative design in Chapter 5 will incorporate a different palette of construction materials, plant communities and other strategies to collectively decrease impervious surface area and reduce stormwater runoff.

Porous materials for paving are a valuable method for limiting the percentage of impervious surface on a site. A range of porous pavements exist that may serve a variety of functions in the landscape. There are porous pavements specifically designed for vehicular corridors such as roads, gutters or parking areas. Other forms of pervious materials serve well for pedestrian areas like plazas, walkways and paths.

The structure and conditioning of soils must also be noted in an overall effort toward improved stormwater management. Compacted soils typical of construction sites have less capacity to infiltrate water than do undeveloped sites. Vegetation generally takes longer to become established and grows relatively slow in heavily compacted soils. There are number of ways in which soil compaction may be addressed. Structural soils may be used in heavily trafficked areas such as dense urban plazas. These mixtures of soil and aggregate provide the necessary support of pavements, and simultaneously allow for the movement of air and water to support vegetation. Additionally, soils may be structurally rehabilitated mechanically or with certain vegetation.

Certain plant communities may lend themselves toward more effective stormwater management. Isolated ornamental trees, foundation shrubs and the obligatory lawn do not typically function well in terms of conditioning soils, intercepting precipitation or slowing runoff. Plant communities that strive to function as a woodland may perform better in terms of stormwater management. Wooded areas are relatively effective in detaining stormwater within their canopies and along their ground layer. The alternative landscape will seek to utilize these forces as another means of managing stormwater.

Certain grading techniques and the use of retaining walls may also serve to manipulate and control the flow of runoff. Terraced landscapes, for example, will cause stormwater to run-off at slower rates than on sloping terrain, essentially providing more time and opportunity for water to infiltrate into soil. Gentle swales that accept small volumes of stormwater may also be incorporated into the landscape between buildings, within parking lots and along roadsides.

Sub-surface detention, and subsequent infiltration near the point where runoff is generated can serve well to manage stormwater in dense or impervious areas. Runoff can be collected and diverted to perforated pipes underground, where it can then slowly infiltrate into the soil.

To conclude, the variety of techniques and materials used in the sound management of stormwater should serve to support both human and ecological function. There is no reason why natural processes should be interrupted even within the confines of the built environment. It will better serve existing natural processes to bring water into contact with soil where it might infiltrate and recharge rather than to divert it into pipes and basins.

CHAPTER 3: NEW URBANISM

New Urbanism is a development type and methodology that has grown in popularity during the past decade as an alternative growth pattern to the pervasive and maligned entity known as suburban sprawl. Suburbs constituted a large percentage of growth in the United States in the decades following World War II. By 1960, approximately one-third of the population resided in some form of suburbia (Thomas, p39). As of 1990, 44% of the United States' population lived in the suburbs (Encyclopedia of cities and suburbs, p756). Suburbia, according to new urbanists, has blurred the distinction between the built and natural environments with homogenous, anonymous and inefficient sprawl. "Suburbs do not have explicit administrative boundaries, they can be part of either urban or rural areas" (Thorns, p20). Sprawl can manifest itself in a variety of forms. It can be a busy road that carries heavy traffic past a row of gas stations and fast food restaurants. It can be a strip mall or a housing development. It is not urban and it is not rural. It is, however, pervasive in our society and has created an environment in which the automobile is a required form of transportation.

The Congress of the New Urbanism (CNU), the foremost new urbanist organization in the United States, was established in the early 1990's by a collection of architects and planners. In the mid-90's, CNU developed its manifesto, The Charter of the New Urbanism (Appendix A-1). The Charter organizes the principles of New Urbanism into three categories: 1. the region: metropolis, city and town, 2. the neighborhood, the district and the corridor, and 3. the block, the street and the building. As these categories imply, new urbanist principles of development and design are geared toward a wide spectrum of geographic scales. A brief review of these three categories will provide an adequate introduction to this design movement and its vision for land use and development.

To summarize the regional planning principles and large-scale initiatives of the Charter, new urbanist development should exist as a cohesive network of coordinated metropolitan areas. These areas should have prominent urban centers and maintain clearly defined boundaries with each other and the surrounding open space. The Charter suggests that it is crucial to delineate between the built environment and the natural environment in order to preserve the identity and function of each individual landscape. For this reason, infill development and densification within defined metropolitan limits is a desirable method of growth. New development, or greenfield development, should be planned and constructed utilizing new urbanist design principles. The new urbanist pattern should include a variety of housing options and a mixture of uses; commercial establishments, civic entities and residences are all necessary components. Mass transit should provide access throughout and between regions as alternatives to typical highway systems.

The second set of principles offered in the Charter of the New Urbanism is entitled the Neighborhood, the District and the Corridor. These entities comprise the essential building blocks of new urbanist metropolitan areas. Neighborhoods are considered very important in new urbanism because they comprise the general area that residents identify as "their own." Neighborhoods must be composed of a legible network of interconnected streets that provide access to homes and businesses. Although neighborhoods should ultimately be designed for the needs of the pedestrian, circulation is naturally provided for the automobile as well. New urbanist neighborhoods must include a variety of uses; retail establishments, civic institutions and open space should be incorporated elements of neighborhoods. Such destinations should be located within walking distance of residents. People should not have to rely on automobiles to access everyday needs and destinations. A variety of housing options should be provided to encourage diversity within neighborhoods. Mass transit systems should be readily accessible.

The third set of principles, titled The Block, The Building and The Street, address the specific elements of a new urbanist neighborhood. Good urban design requires recognizable patterns in order to identify space. New Urbanist streets should first and foremost be designed for pedestrians. Architecture and landscapes should reflect a sense of local history and environment. Important civic and public spaces should be sited in prominent locations. Buildings should be legible and should function efficiently. Their proximity to the road and to one another is important to create interesting and notable spaces.

The *Smart Code* will serve as another primary reference for information specific information about traditional neighborhood development; it contains general guidelines, specific directions and a complete assortment of minimum standards for the development of new urbanist communities (Duany Plater-Zyberk, 2006). Essentially, the *Smart Code* is the new urbanist alternative to municipal planning codes that govern growth and development throughout the United States.

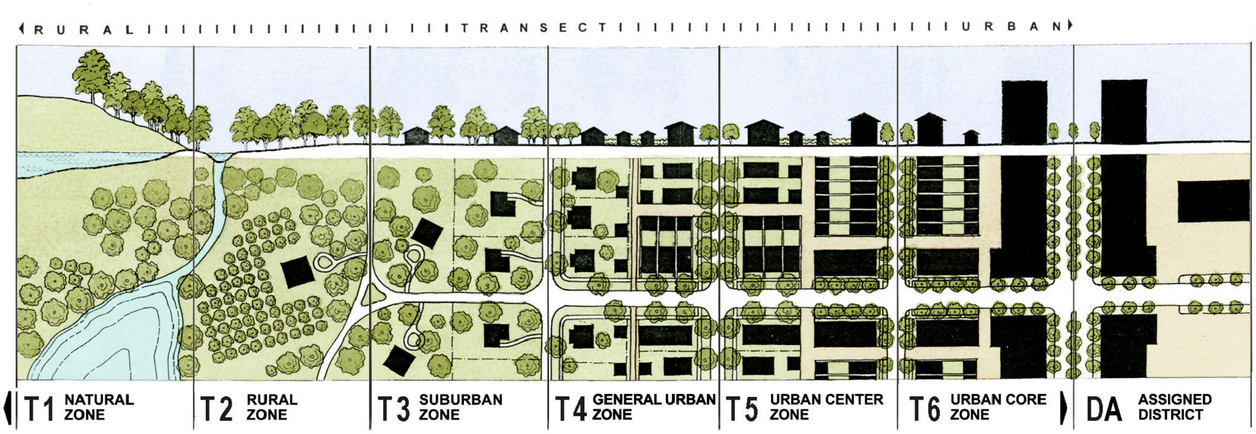


Figure 3-1: The Transect by DPZ & Co.

The *Smart Code* uses a graphical method, referred to as The Transect, to illustrate land use and relative density across a rural-urban continuum in a new urbanist setting (Figure 3-1). Transect Zones (T1-T6) refer to classifications of the new urbanist landscape as defined in the Smart Code. Each of the zones represents a distinct relationship between the built and natural environments. The *Smart Code* seeks to define a series of "quality environments" in order to recognize and encourage the chosen character of each particular place, whether it be urban or rural. Transect Zones of the case study in Chapter Four will therefore be identified in order to help define the specific regions of the proposed development.

CHAPTER 4: CASE STUDY

Vickery, a Traditional Neighborhood Development currently under construction on a 214.75 acre site in Cumming, Georgia will serve as the case study for this thesis (Figures 4-1 & 4-2); it was selected as the case study due to the fact that it was planned by Duany, Plater-Zyberk & Co., arguably the most notable authorities of new urbanism, and because detailed information about the site was available. It was important to utilize such a typical New Urbanist community as the case study; in doing so, one can presume that alternative stormwater management strategies offered in Chapter Five may be applicable to other new urbanist developments as well, regardless of the designer. Chapter Four will first present information about the predevelopment site. Following this will be a detailed analysis of DPZ & Co. illus-

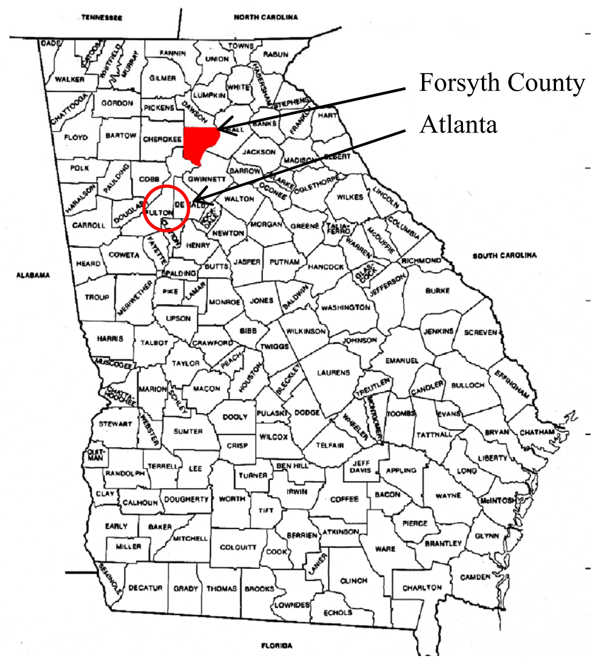


Figure 4-1: Counties of Georgia

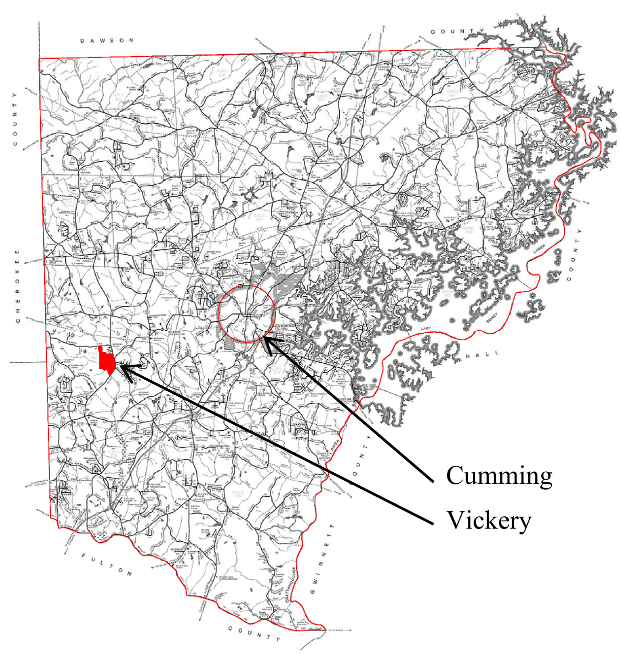


Figure 4-2: Forsyth County, Georgia

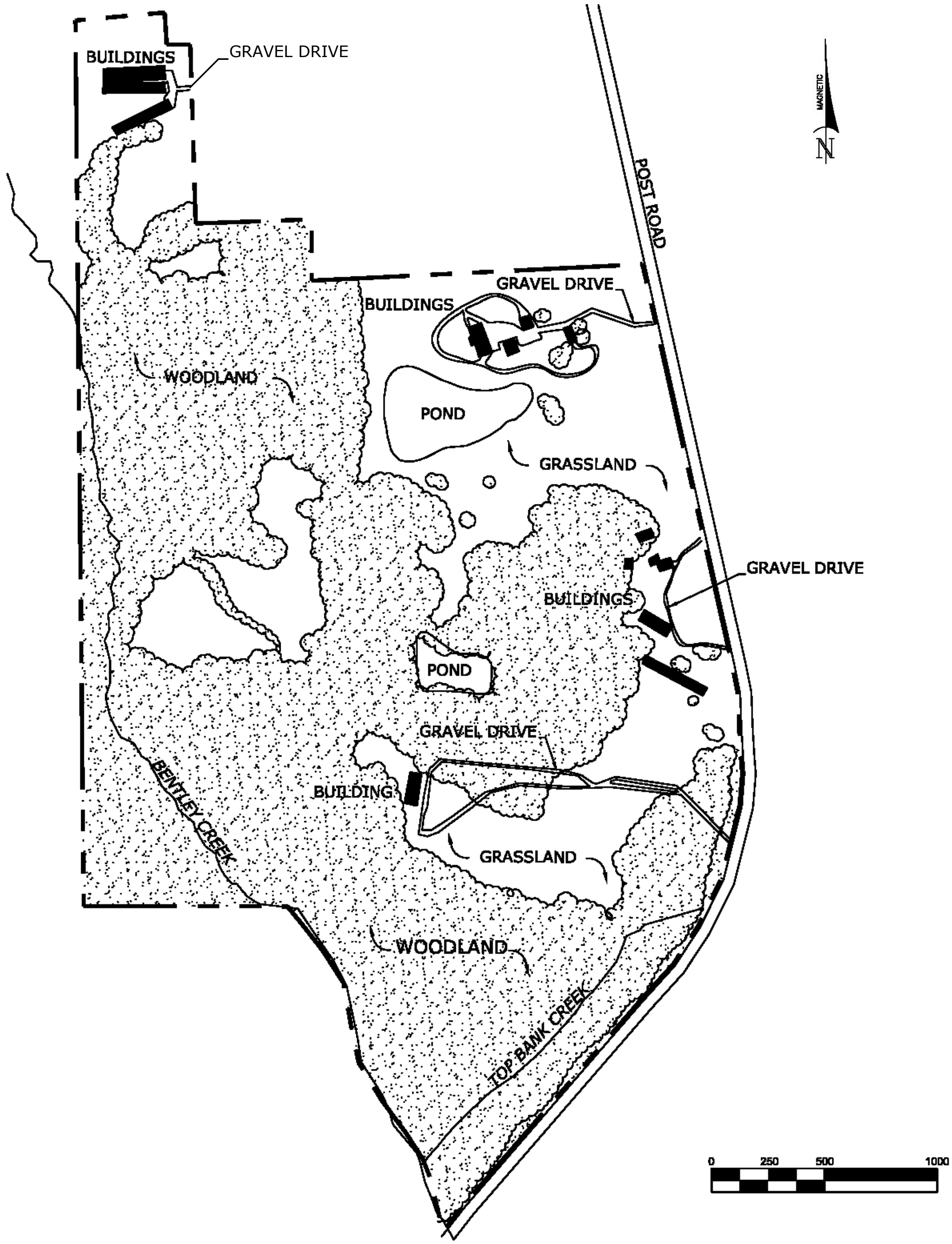


Figure 4-3: Predevelopment Site

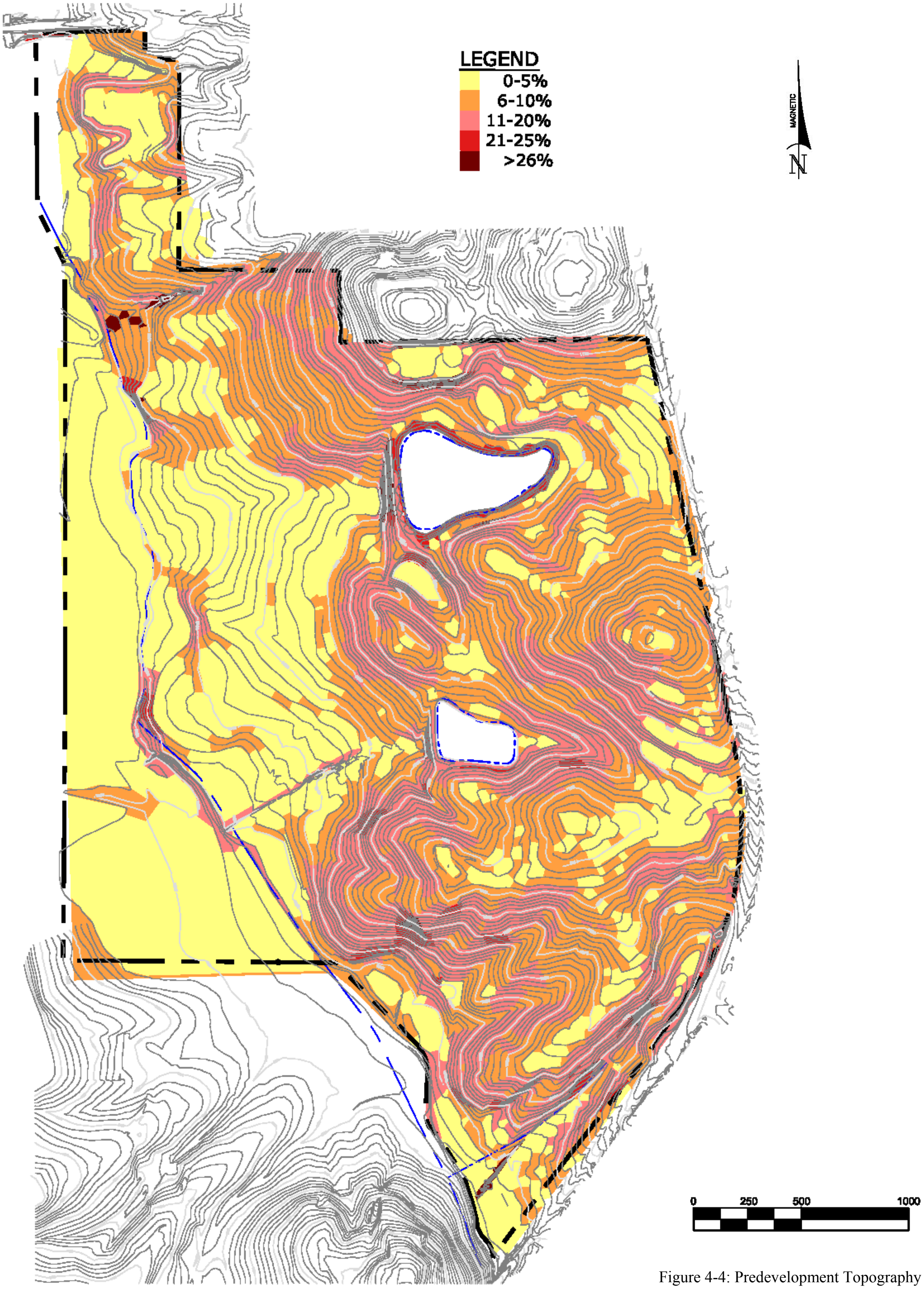
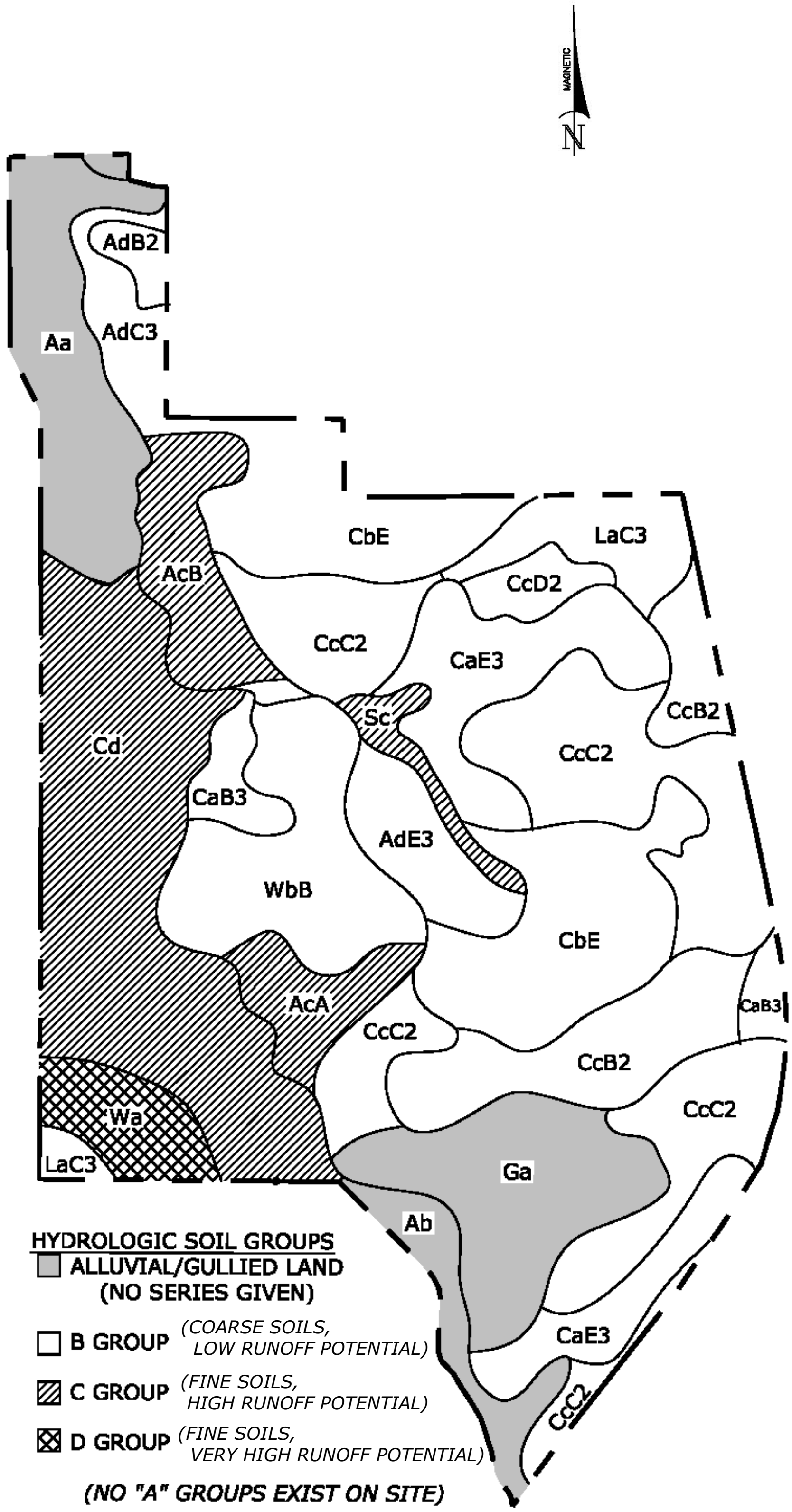


Figure 4-4: Predevelopment Topography



SERIES		HYDROLOGIC SOIL GROUP
Aa	-Alluvial land, poorly drained	N/A
Ab	-Alluvial land, moderately well drained	N/A
AcA	-Altavista fine sandy loam, level phase	C
AcB	-Altavista fine sandy loam, very gentle slopes	C
AdB2	-Appling sandy clay loam, eroded, very gentle slopes	B
AdC3	-Appling sandy clay loam, severely eroded, gentle slopes	B
AdE3	-Appling sandy clay loam, severely eroded, moderate slopes	B
CaB3	-Cecil clay loam, severely eroded, very gentle slopes	B
CaE3	-Cecil clay loam, severely eroded, moderately steep	B
CbE	-Cecil fine sandy loam, moderately steep	B
CcB2	-Cecil sandy loam, gentle slopes	B
CcC2	-Cecil sandy loam, eroded, gentle slopes	B
CcD2	-Cecil sandy loam, eroded sloping phase	B
Cd	-Chewacla silt loam	C
Ga	-Gullied land, acid materials	N/A
LaC3	-Lloyd clay loam, severely eroded, gentle slopes	B
Sc	-Starr loam	C
Wa	-Wehadkee silt loam	B
WbB	-Wickham fine sandy loam, very gentle slopes	B

Figure 4-5: Soils

trated plans for Vickery; these include a master plan and three site-specific plans of the community.

The predevelopment site is illustrated in Figure 4-3. This image is a digitization of an aerial photograph. Approximately 64% of the predevelopment site was wooded. 34% of the site was cleared grassland. Approximately 14 structures existed including what appear to be several chicken houses. These buildings were connected to Post Road by what appear to be unpaved (gravel) driveways.

Topographical information for the site can be viewed in Figure 4-4. There is approximately 100 feet of relief from the upper ridges of the eastern half of the site to the meandering creek near the western property line. Existing slopes range from 0 to 5% along ridges and floodplains to significant slopes of 25% or more along drainage routes. Vickery exists several miles west of Lake Lanier within the Upper Chattahoochee Watershed. The creeks that flow across the site are tributaries of the Chattahoochee River.

Existing soils of the site can be seen in Figure 4-5; information was gathered from the Natural Resources Conservation Service (NRCS, 1960). Surface soils of the area are sandy loams or sandy clay loams overlying predominately clay B horizons. Most soils are considered to have moderate infiltration rates. Hydrologic Soil Groups were taken from the Georgia Stormwater Management Manual (Appendix B, 2001).

The Illustrative Master Plan of Vickery (Figure 4-6) was developed by a Charrette Team led by Andres Duany in June, 2002. The orange buildings shown in the plan comprise the proposed commercial, civic and retail establishments of the development. Multi-family housing lots and single-family detached housing lots are displayed in yellow. Areas of open space are shown in green; these include a greenway along Bentley Creek as well as several parks and amenity areas around the two ponds. The network of roads at Vickery form a connected, yet

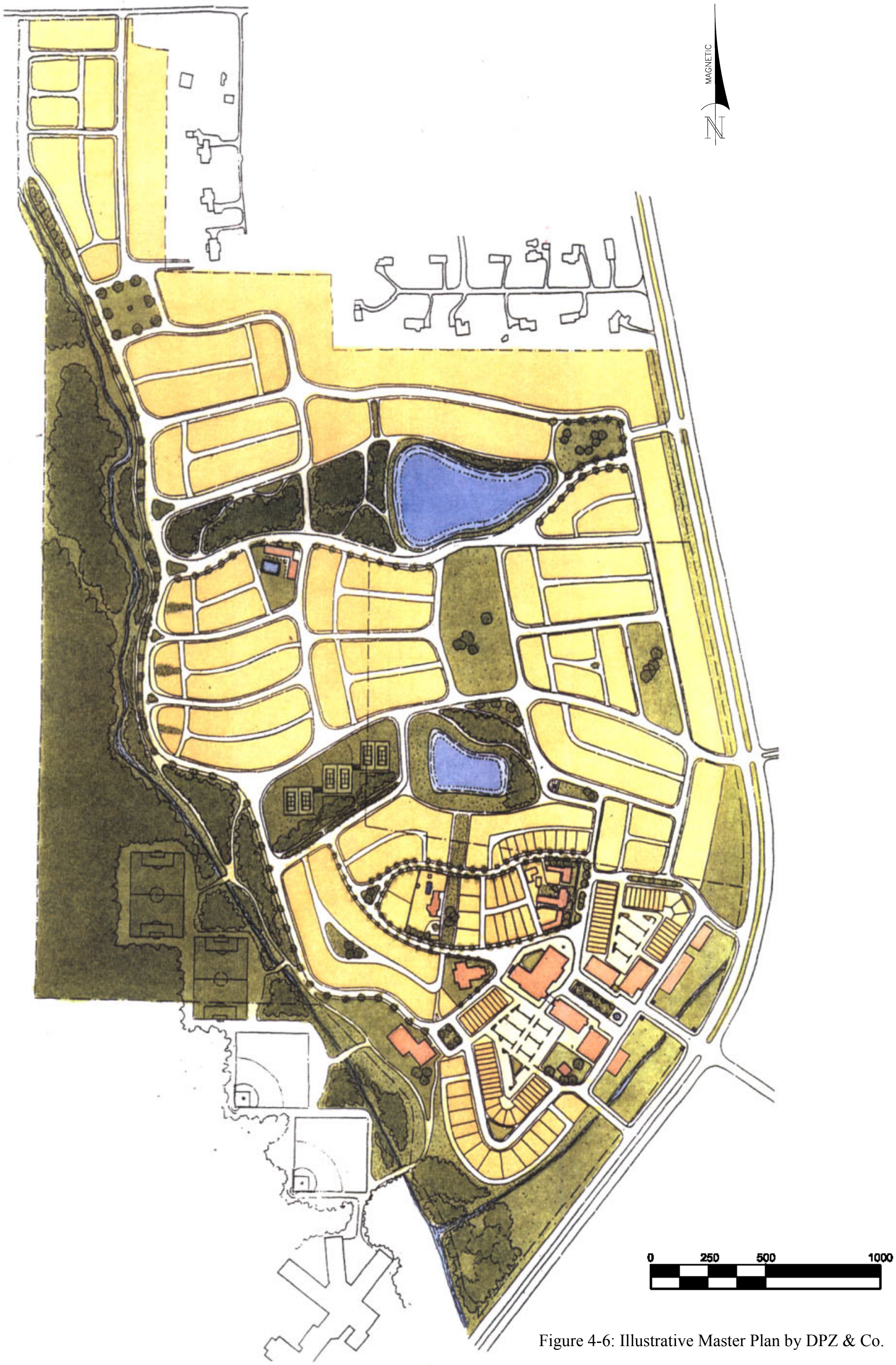


Figure 4-6: Illustrative Master Plan by DPZ & Co.

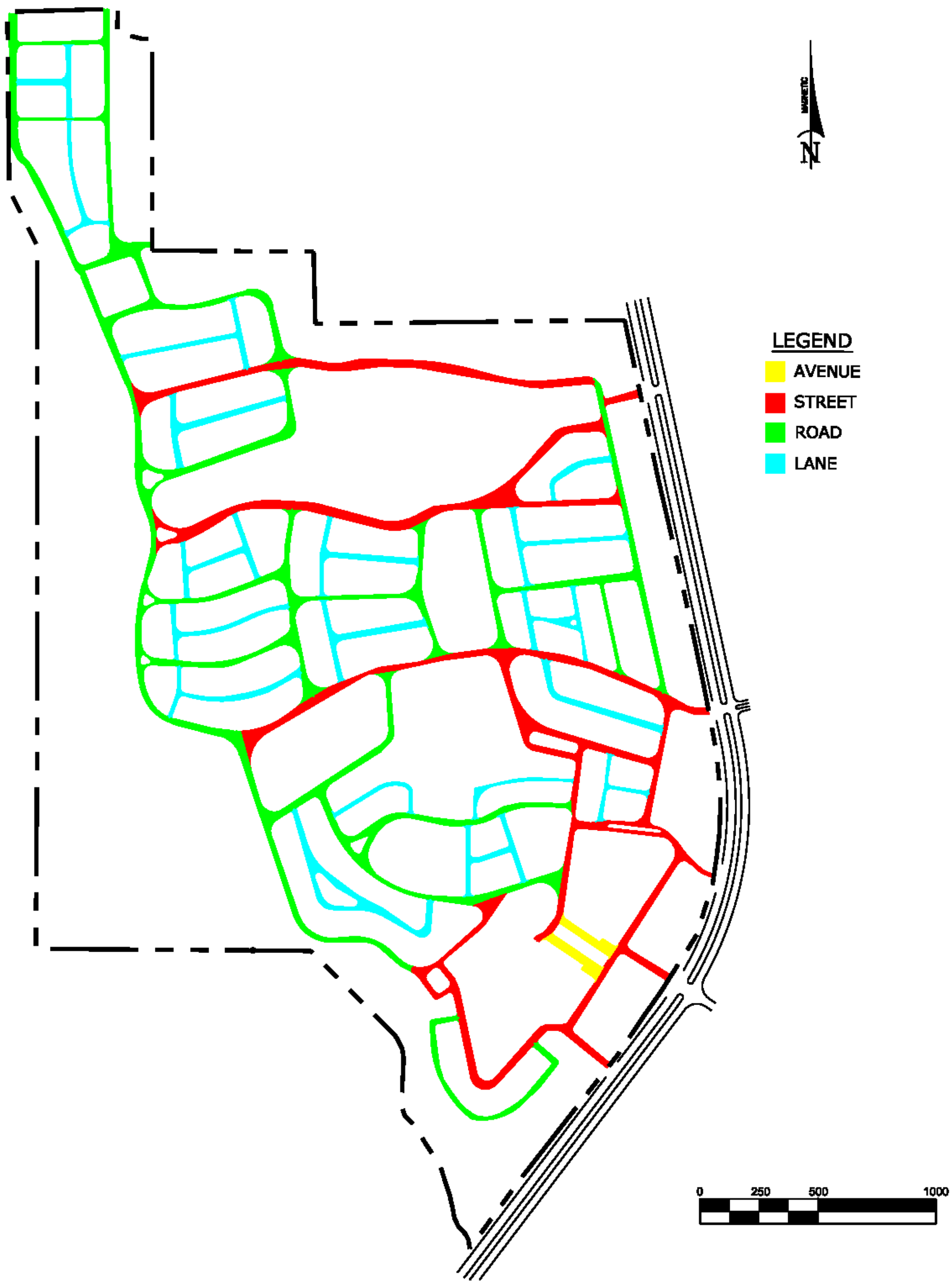


Figure 4-7: Thoroughfare Classifications

irregular grid. Figure 4-7 identifies the four general classifications of vehicular thoroughfares: avenues, streets, roads and lanes; these classifications were specified by DPZ & Co. (Vickery Charrette Book, p 34).

In addition to the Illustrative Master Plan, several site-specific plans of Vickery were developed by the Charrette Team. These site-specific plans are presented at a larger scale and display a greater level of detail than is shown in the Illustrative Master Plan. These site-specific plans more specifically identify the different regions of the community and the intent of its planners.

Building Key

1. Library
2. YMCA
3. Chapel
4. Restaurant
5. Retail
6. Kid's Clubhouse
7. Meeting Room
8. Offices
9. Live/Work Units & Townhouses
10. Existing Building
11. Commercial Buildings

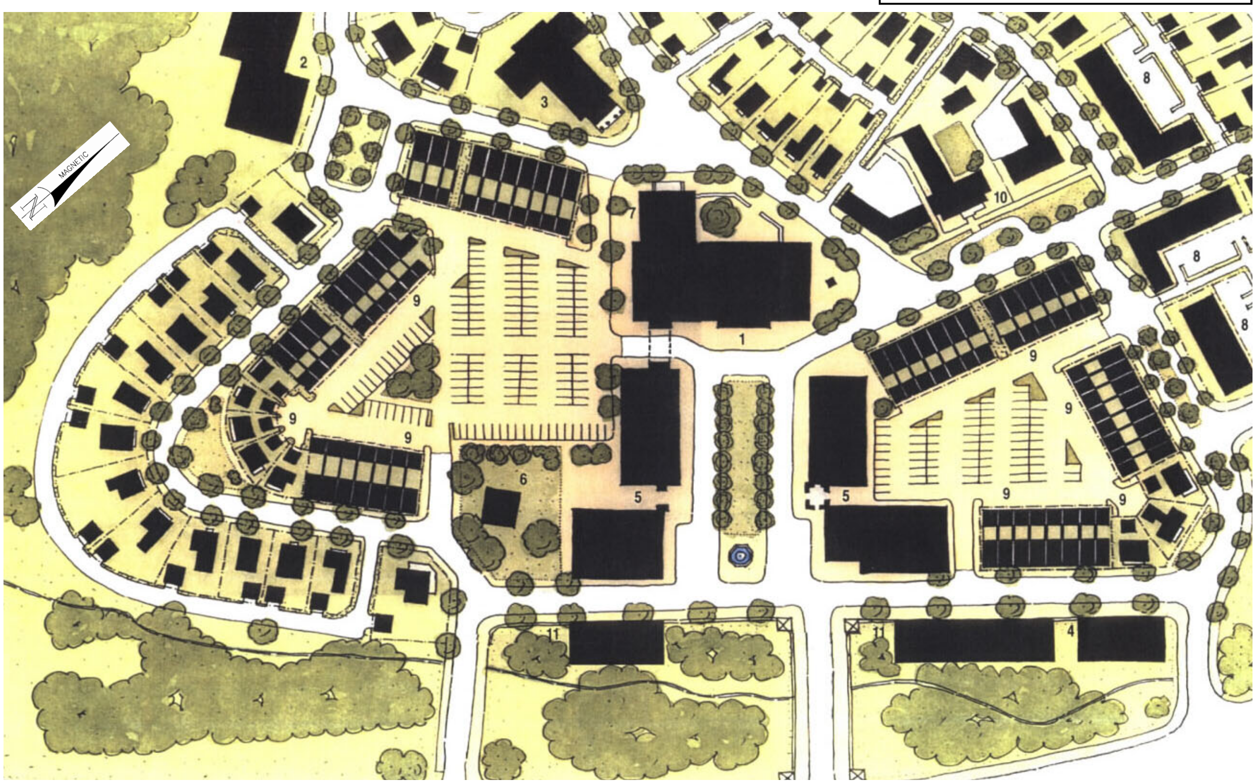


Figure 4-8: T-5 Site Specific Plan by DPZ & Co..

Site Specific Plan #1: T5 Zone (Urban Center)

Figure 4-8 shows the Village Center of Vickery; in Transect terms, this comprises the T5 area of the development. This area corresponds to the primary entrance off of Post Road.

The prominent avenue is lined with shops and terminates into a focal point of Vickery, the library. The avenue consists of two 30' wide, 1-directional sections of pavement, each consisting of a driving lane and on-street diagonal parking (Figure 4-7). Between these lanes is a central green, lined with sidewalks and street trees. On either side of the avenue, 4' planting strips separate the sidewalk from the street; street trees are proposed at 30' on center. 10' wide sidewalks lead directly to shop fronts. Because it is not stated otherwise, it is assumed that all these pavements are intended to be typical impervious asphalt and concrete.

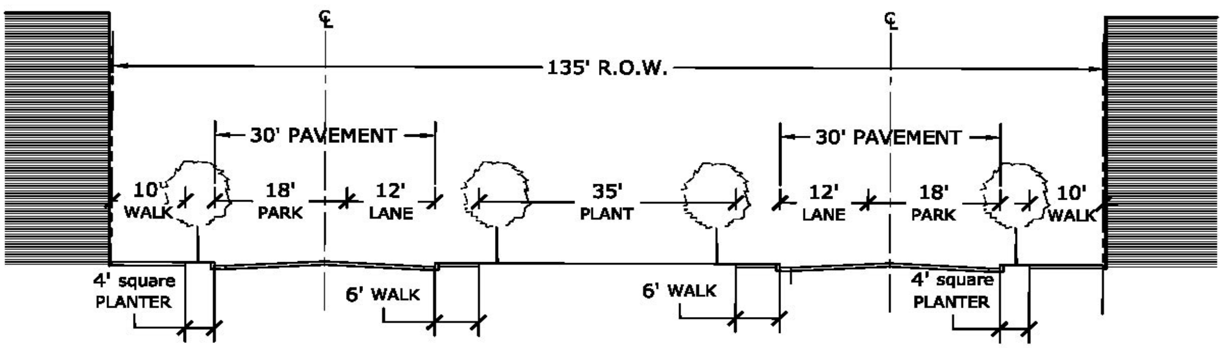


Figure 4-9: Avenue section

Behind each set of shops is an off-street parking lot. These lots provide parking for various shops as well as vehicular access to the garage units of adjacent multi-family housing. Several of the office buildings in the upper right corner of this site-specific plan also appear to have some proposed off-street parking. Proposed parking lots appear entirely paved with only a few small parking lot islands and trees. Because it is not otherwise stated, it is assumed that these lots are paved with impervious asphalt.

Both multi-family and single-detached housing units are proposed within close proximity of the Village Center (Figure 4-9). Each of these units consists of a dwelling and a detached garage. Garages on single-family lots are accessed from the rear by a secondary network of vehicular thoroughfares. Although sizes vary, these single-family lots are relatively small when compared to those in the further reaches of the development.

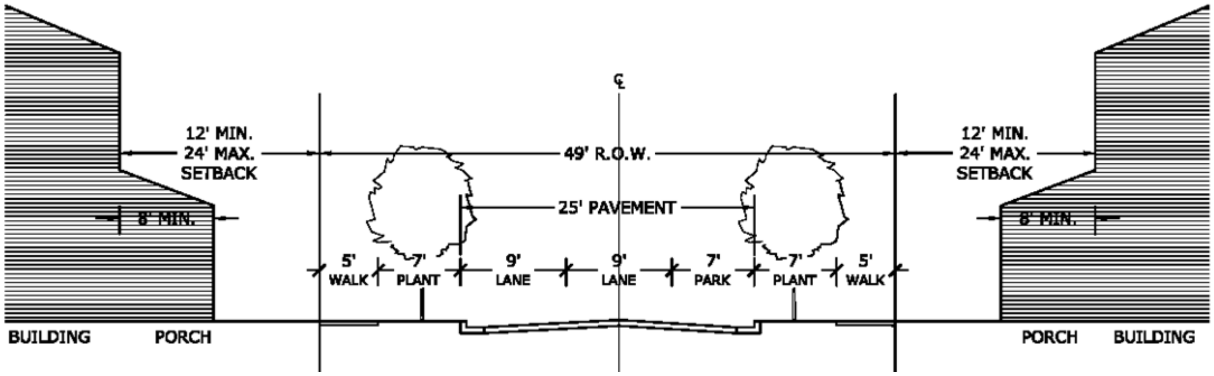


Figure 4-10: Typical Street Section

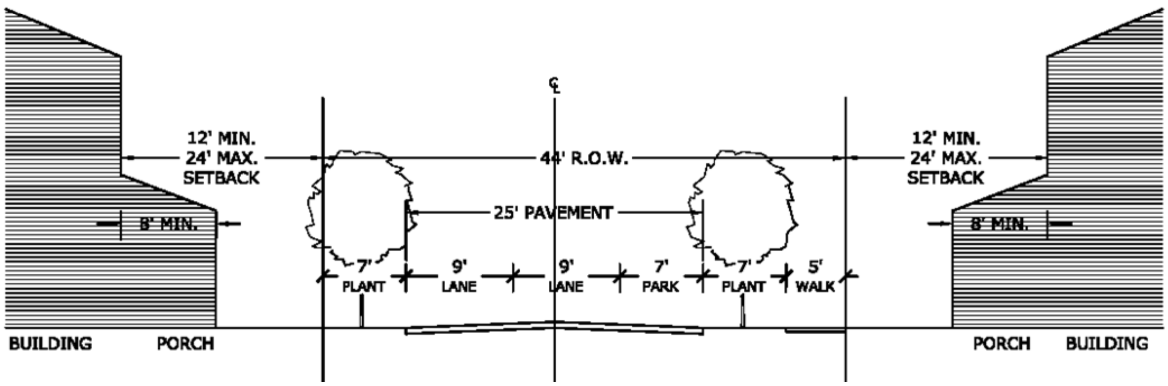


Figure 4-11: Typical Road Section

A variety of streets and roads form an interconnected grid of vehicular corridors. Numerous sub-classifications of streets and roads are defined and identified by DPZ & Co. Sub classifications differ in their right-of-way width, pavement width, the presence of on-street parking or the presence of sidewalks on one or both sides of the corridor. Streets, the primary thoroughfare type, typically utilize curb and gutter; roads do not (Figures 4-10 and 4-11).

In addition to the existing woodlands and riparian habitat that surround two sides of the Village Center, approximately 27,000 square feet of fragmented open space is included within the interior of this site-specific plan. The main avenue's central green was already noted as a prominent, if minute, portion of green space. There is also a small park associated with the "Kid's Clubhouse," just west of the avenue and shops. Additionally, one may find several other areas of vegetated ground amidst the interstices of streets and sidewalks. These spaces may not be large enough to serve as "active" open space, but could help to soften and beautify the surrounding collection of buildings and roads.

Site Specific Plan #2: T4 Zone (General Urban Zone)

The second site-specific plan presented by DPZ & Co. is representative of the T-4 zone of the Transect (Figures 4-12 and 4-13). Close in proximity to the Village Center, this block contains both residential and commercial uses. Several of the structures were existing prior to the construction of Vickery; it is logical to assume that this plan was developed for this very reason. It was important to show how the existing buildings would be utilized in the proposed plan for this new urbanist neighborhood.

The middle of the three buildings on the side of the block is referenced as existing (Vickery Charrette Book, p21). Due to the fact that off-street parking is proposed behind the outer two buildings, it is presumed that these buildings are for some sort of commercial use such as office space. Off-street parking lots are accessed from the rear by a narrow lane. A designated drop-off lane for the center (existing) building, is separated from the primary street by a small median.

The remainder of the block is predominately single-family housing lots. The nine lots proposed directly to the west of the commercial buildings represent the typical new urbanist layout; homes are sited close to the road (12' maximum front setback) and detached garages are accessible via a secondary network of narrow (8'), 1-directional lanes.

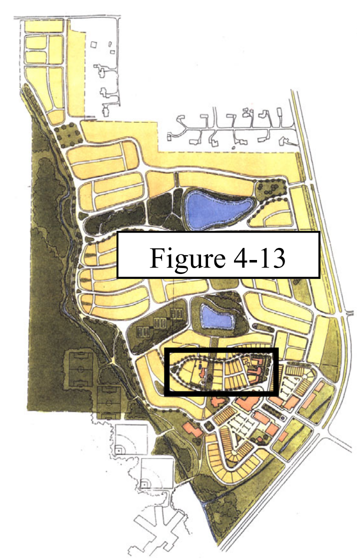


Figure 4-12: Illustrative Master Plan by DPZ & Co.

The configuration of the remaining lots within this block are not typical of new urbanist development. Five

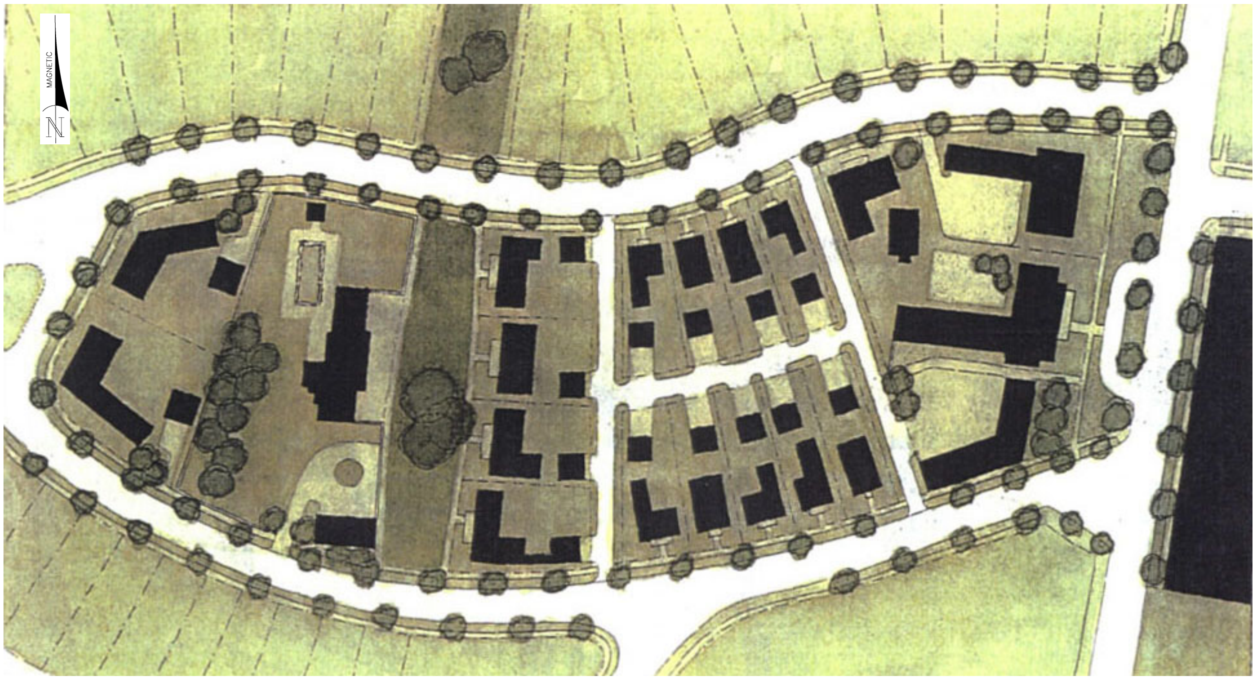


Figure 4-13: T-4 Site-Specific Plan by DPZ & Co.

homes are oriented toward a narrow portion of open space that bisects the block. The large home on the western edge of the open space is an existing building. The open space to which it faces is shown to contain several large existing trees. The homes on the eastern side of the park were successfully arranged to create a sense of order in what would otherwise have been an awkward layout. The middle two homes on this eastern side do not have any true road frontage; perhaps this might be considered a preferable situation to some.

The two large homes proposed for the western end of the block also do not represent the typical new urbanist layout. Detached garages of each are accessed directly from the road, not from a secondary lane. It is presumed that the unusual layout of these homes is due to existing site constraints such as steep topography and the conservation of existing vegetation.

The vehicular corridor that runs north-south along the eastern side of this plan is a large street. It provides on-street parking, 7' planting strips and 5' sidewalks on both sides. Street trees are typically proposed at 30' o.c. The proposed thoroughfares that run parallel from east to west are residential roads. DPZ & Co. specifies on-street parking and a sidewalk on only one side for this type of road. Curb and gutter are not typically proposed for roads. Street trees are to be 30’ o.c.

Site Specific Plan #3: T3 Zone (Suburban Zone)

The third site specific plan produced by DPZ & Co. is representative of the T-3 zone of the Transect (Figures 4-14 & 4-15). This is the “suburban” portion of the development, consisting solely of single-family detached housing lots. These lots are generally wider (ranging from 55’ to 75’) than those shown in the T4 Zone (ranging from 35’ to 45’). Buildings are spaced further from the road (24’ maximum) than in the more dense portions of the development (12’ maximum). The lots along the western edge of this plan are on particularly large lots. These are in a unique position in that they do not face other buildings, but instead face Bentley Creek and its associated open space. All homes are shown with porches and walkways that lead to the property line. Detached garages are typical.

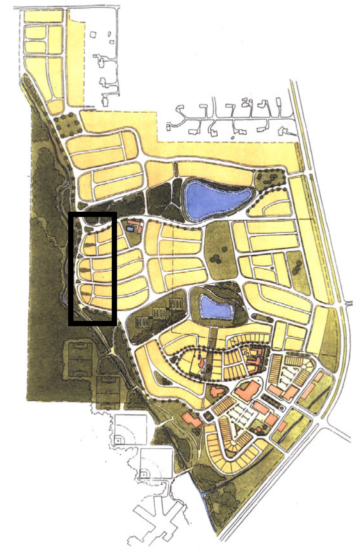


Figure 4-14: Illustrative Master Plan by DPZ & Co.

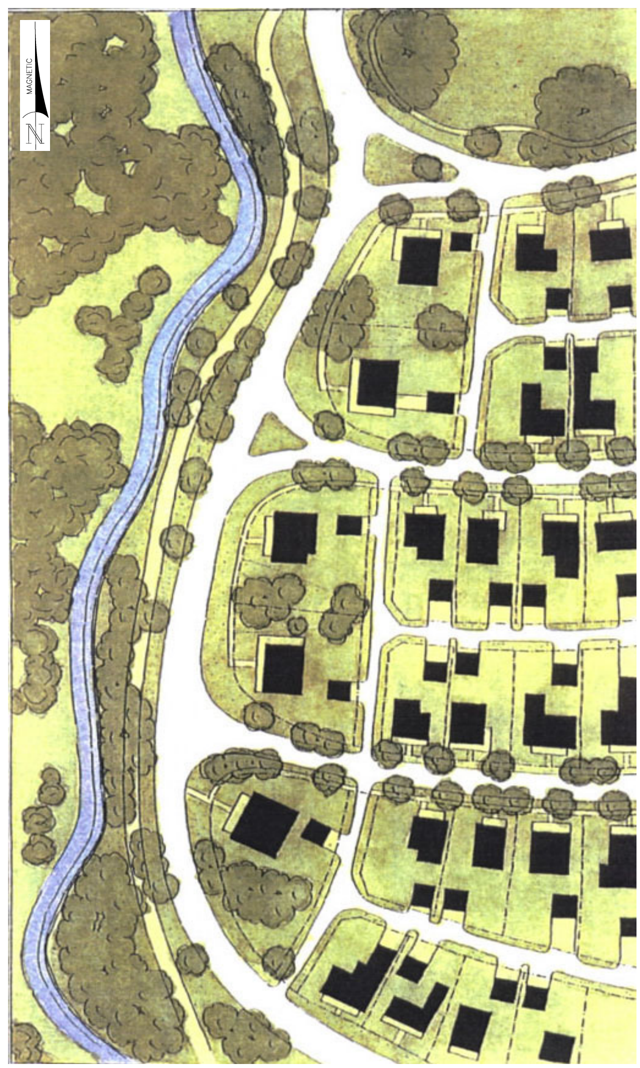


Figure 4-15: T-3 Site-Specific Plan by DPZ & Co.

The residential street that runs parallel with Bentley Creek is intended to be a scenic drive. It maintains on-street parking, a 7' wide planting strip and 5' sidewalk on the developed side, and does not utilize curb and gutter. A greenway is proposed along the undeveloped side of this street.

The primary, tree-lined roads that run from east to west form an interconnected grid with the secondary network of narrow lanes. Roads are specified with on-street parking and a 5' sidewalk on one side. The sidewalk is separated from the road by a 7' wide planting strip. Lanes are specified as 8' wide paved surfaces, bordered on each side by 8' of vegetated surface (24' right-of-way).

Combined, the Illustrative Master Plan and three Site-Specific Plans provide a complete representation of the character and proposed land use at Vickery. These same areas will be used again in the following chapter to demonstrate alternative stormwater management techniques. An investigation of what is possible within these areas will result in a series of guidelines and recommendations that may be applied to the entire development.

CHAPTER 5: AN ALTERNATIVE LANDSCAPE

This chapter will explore alternative stormwater management techniques within Vickery's given layout of buildings, roads and other development elements described in Chapter Four. Rather than using conventional methods of conveying stormwater from impervious surfaces to extended detention basins, an alternative landscape will be proposed within the layout that utilizes several basic strategies.

1. Stormwater will be brought into contact with the soil as frequently as possible within the development; it will be slowed down, stored, and allowed to infiltrate into the ground. This technique is particularly important in terms of limiting excessive runoff, improving water quality and recharging groundwater supplies.
2. The percentage of impervious materials used for pavements will be reduced. Impervious coverage is directly linked to the volume of runoff generated on-site.
3. The percentage of tree canopy coverage will be increased. Tree canopy intercepts rainfall and ameliorates urban heat effects. Biomass creates and conditions soils and increases infiltration capacities.

The Illustrative Master Plan and three Site-Specific plans from the Vickery Charrette Book were scanned and digitized to produce the plan images that will be used in this chapter.

Digitized Charrette Book plan images are displayed in hues of gray. Additional or alternative information by the author is presented in color. This is done to clearly delineate what was proposed by DPZ & Co. and what is proposed by the author. Sections and details of the alternative landscape's primary components are not shown in color; important information regarding these landscape materials and systems is identified with text.

On-street parking areas and curb and gutter, which were not included in DPZ & Co. illustrated plans, were added to digitized illustrations as specified by DPZ & Co. (Vickery Charrette Book, p35-38).

No grading plan was available for the Vickery development. Therefore, the predeveloped, existing contours of the site were used as indicators of final grades. Each site-specific plan will include further explanation and detail of existing grades.

Approximately 80 acres of open space were proposed for Vickery (Charrette Book, 2000). The large areas of proposed open space associated with Bentley Creek, Top Bank Creek and the two ponds will not be utilized to manage stormwater in the alternative landscape for two main reasons:

1. The percentage of open space proposed for Vickery is unusually high (approximately 38% of the development. This is a wonderful asset to the community and its residents, but for the purposes of this study, the acreage beyond the limits of construction is arbitrary. In order to apply the methods and guidelines of this thesis to other communities, only the open space associated with developed areas of this project (approximately 19.41% of the total open space) will be included in coverage counts of Chapter Six.
2. Much of the open space associated with the creeks is within the minimum required stream buffer of many municipalities.

Figure 5-1 displays the delineation of open space inside and outside of the development zone, as approximated by the author.

Figure 5-1: Digitized Plan of Vickery. Open space within the development zone is shown in green. Open space outside of the development zone is represented with cross-hatch.

Site Specific Plan #1: T-5 Zone

Stormwater management of the alternative landscape will begin at the T5 Zone of Vickery for two main reasons. First, it is the most densely developed portion of the project and will potentially generate the greatest volume of runoff from its impervious surfaces. Secondly, the Village Center is located on top of a ridge; if unmanaged, runoff generated here will flow downhill toward Bentley Creek, creating a greater problem as it goes. In order to prevent the negative consequences of unbridled runoff, stormwater will be managed near its point of contact with the earth. It will be an alternative to the conventional system of culverts and detention basins. Figure 5-2 displays stormwater management strategies for the T5 Zone.

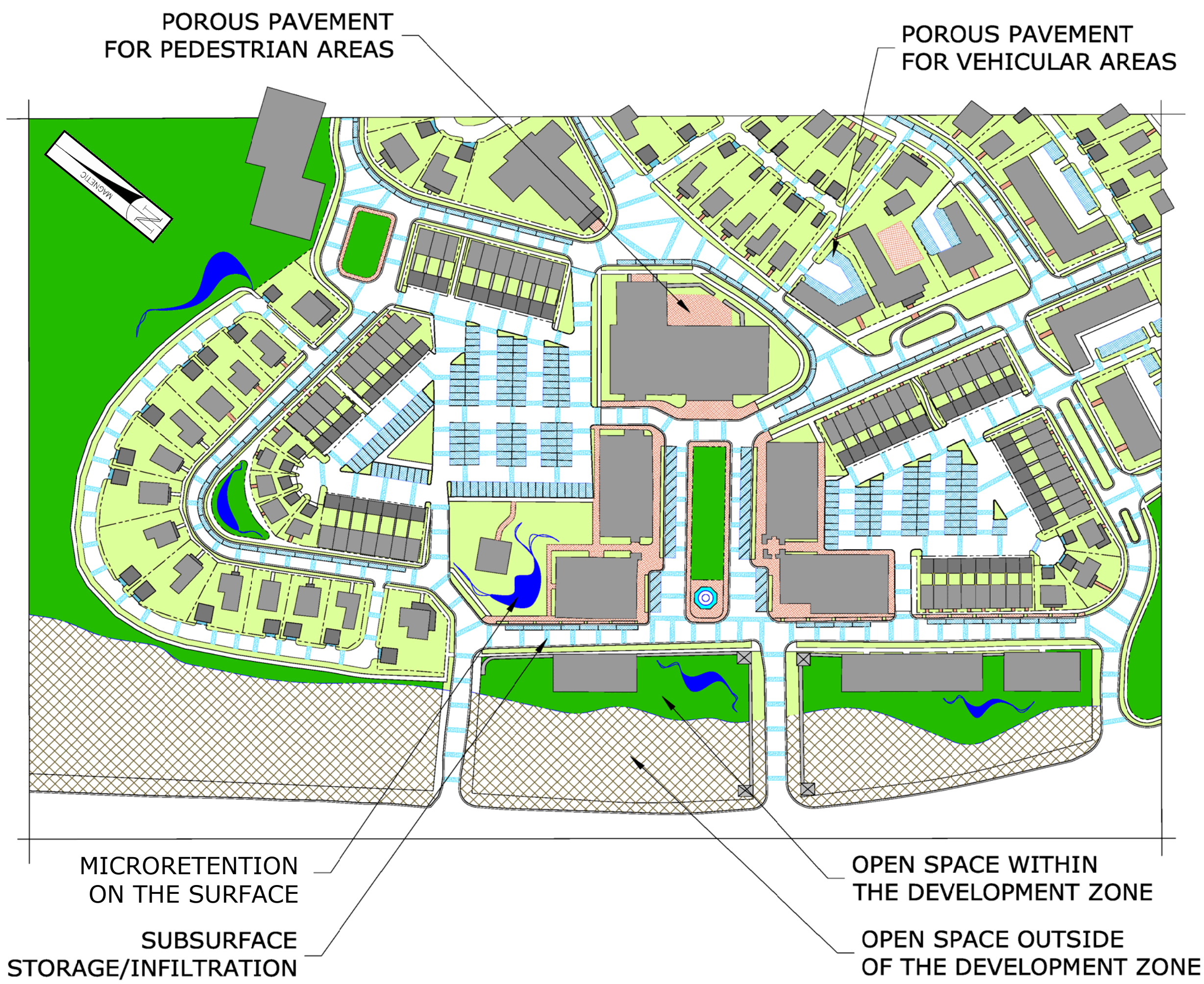


Figure 5-2: Alternative Landscape of the T5 Zone

If one were to overlay the proposed footprint of the immediate Village Center over the predevelopment contours of the area, they would find that there is approximately a 20' difference in elevation between the building on the right side of the avenue with those on the left side. However, illustrative perspectives DPZ & Co. present a Village Center on what appears to be level ground. Although this discrepancy exists, the alternative landscape will acknowledge the rendered perspective as the true intent of Vickery's planners. Finished grades will be presumed to fall from the east to

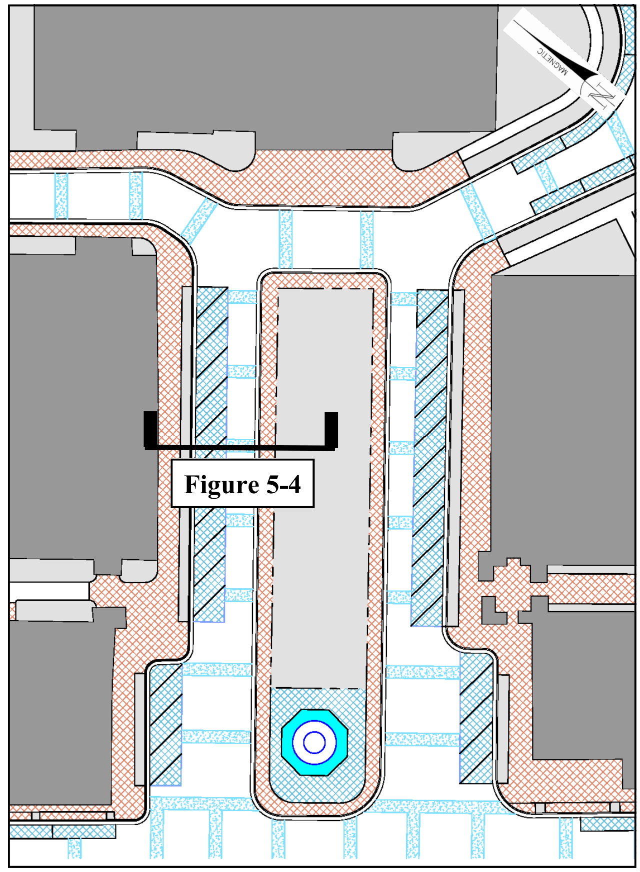


Figure 5-3: Central Avenue of the Alternative Landscape

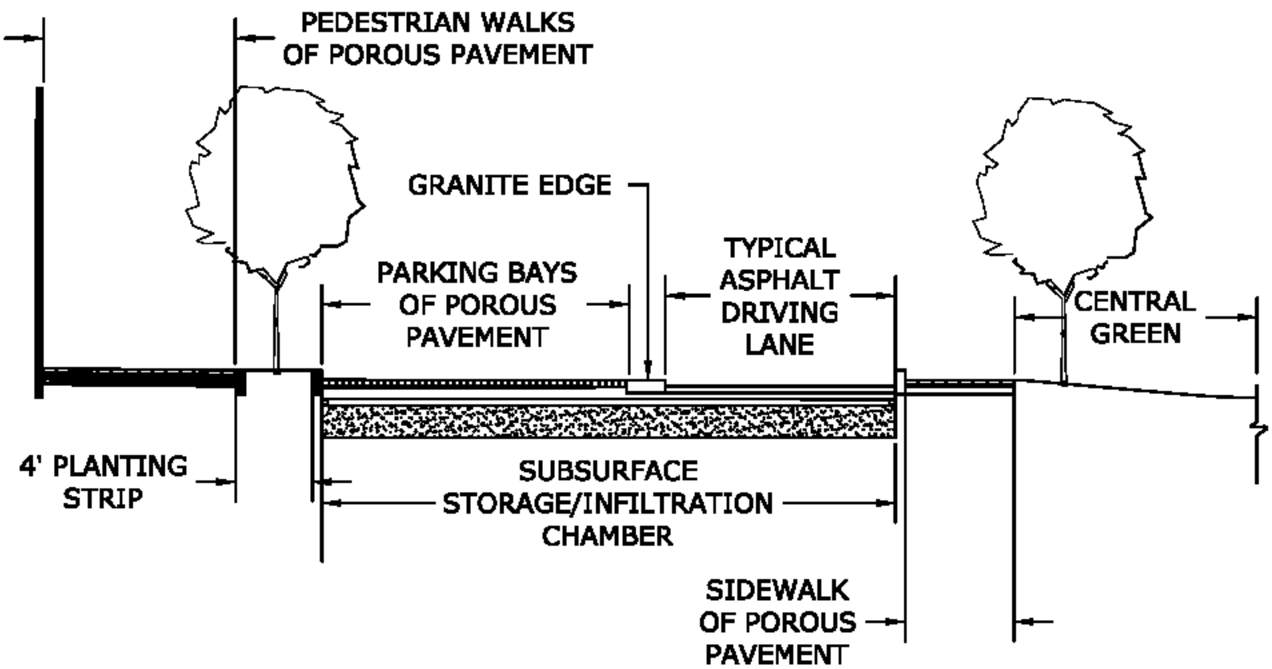


Figure 5-4: Central Avenue Section

west at a gentle 2% slope. This finished grade will enable the buildings of the Village Center to relate to one another as a cohesive space.

Several typical cross sections of the T5 Zone will be elaborated upon in order to demonstrate alternative stormwater management techniques of the alternative landscape; these sections will include the Central Avenue, Off-Street Parking Lots and a Typical Street.

Avenue:

Figure 5-3 is a plan of the immediate Village Center. Figure 5-4 displays a section through the central avenue and green of the Village Center. The different portions of the section will be detailed in the order that they appear from left to right in this section.

Sidewalks of the Village Center will be constructed with red SF Rima™ pavers (see Appendix A-6 for product specifications). Not only will this porous pavement infiltrate runoff, it will also visibly distinguish these prominent pedestrian zones. Joints and bedding for the units

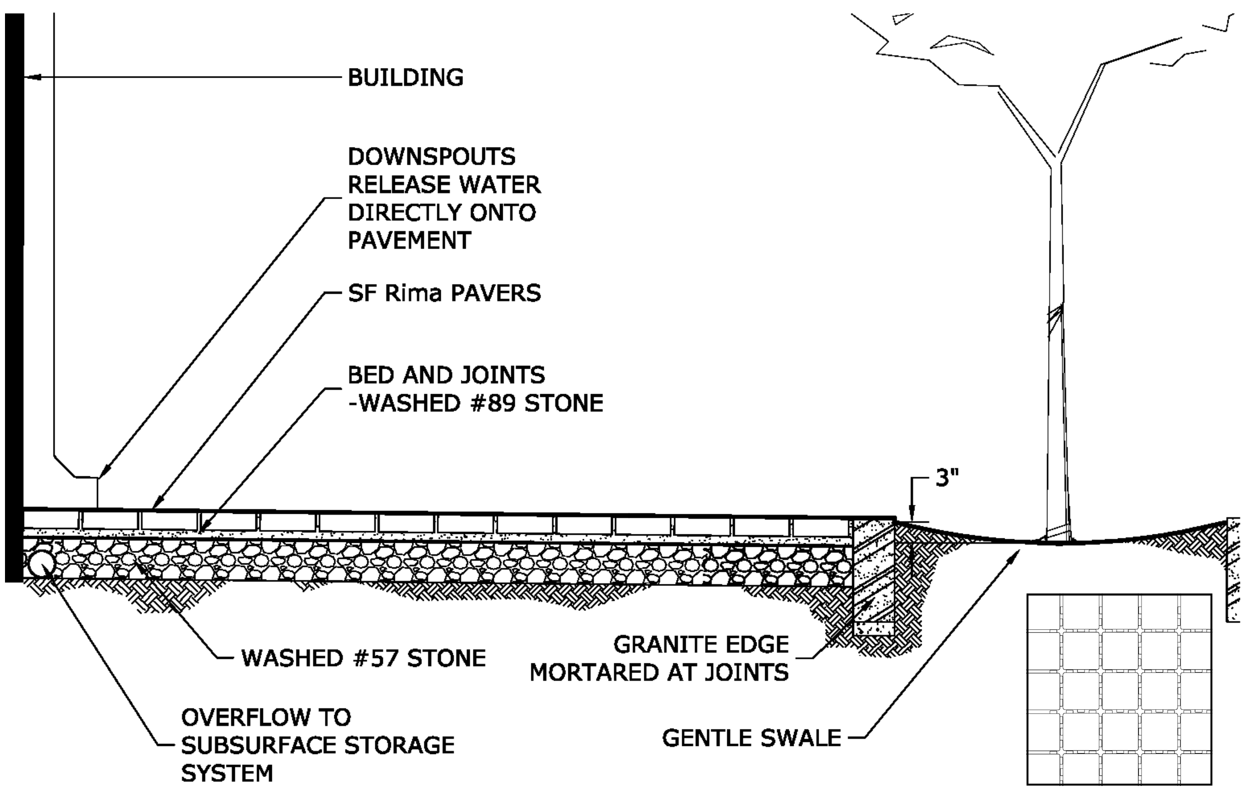
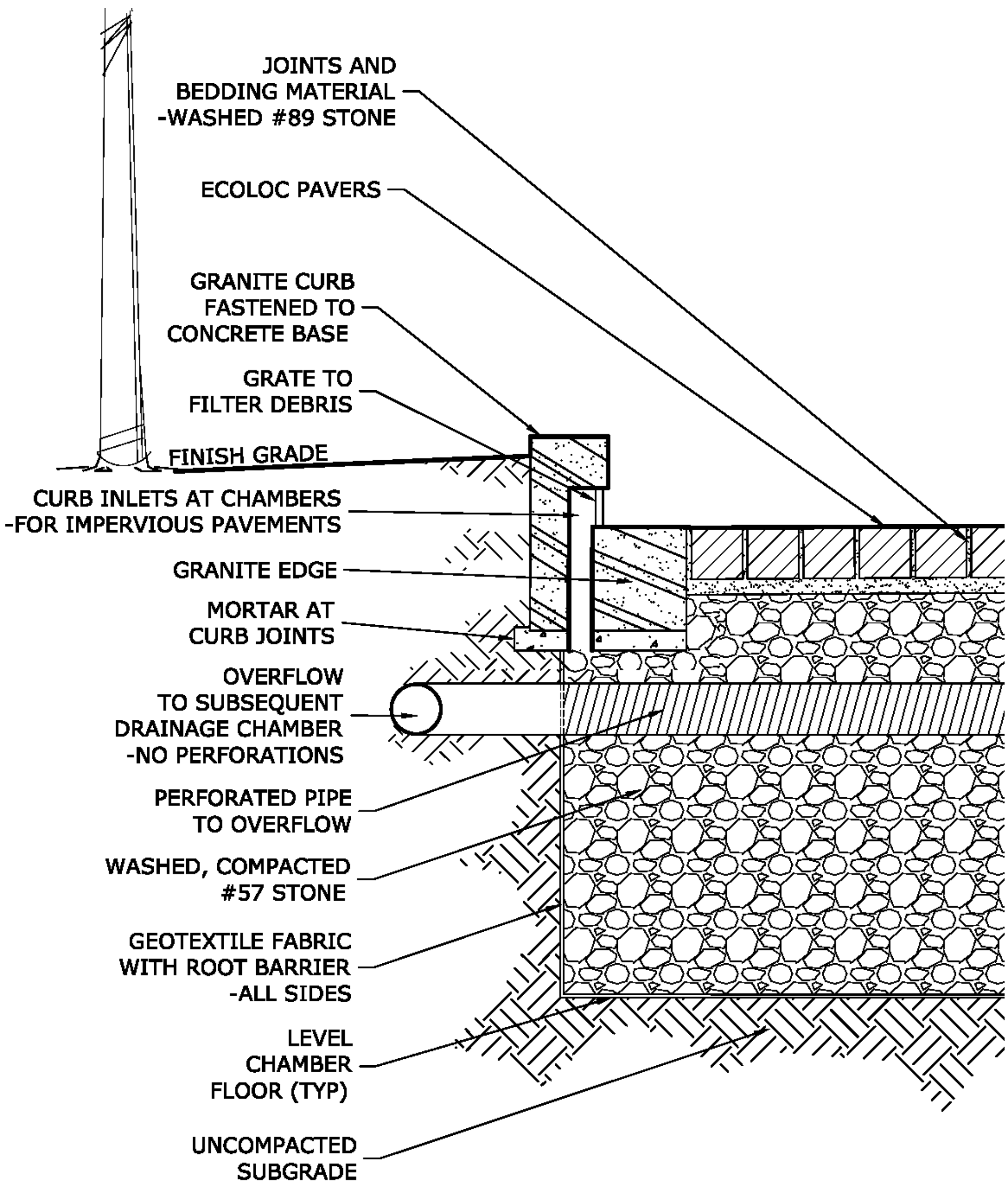


Figure 5-5: Porous Pavement for Pedestrian Areas (Section)
Figure 5-6: Paver Pattern

will be washed #89 stone, an aggregate that is fine enough for block leveling, but large enough that its pore space has adequate infiltration capacity.

The 4' wide planting strips that separate the sidewalk from the street should maintain a subtle swale; the low point of the swale being only several inches lower that the associated side-walk. Grades of these planting areas must not be steep because they will be crossed regularly by people moving to their parked cars and crossing the street. For this reason, they should be



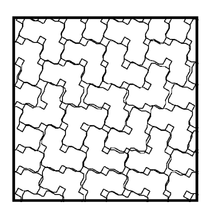


Figure 5-7: Porous Pavement for Parking Bay (Section)
Figure 5-8: Paver Pattern

vegetated with turf grass and evenly spaced street trees. Planting media should possess adequate infiltration rates so as not to hold water for more than 24 hours. These planting strips will not have significant storage capacity, but they will be able to accept the first flush from light showers.

Diagonal parking bays will be constructed of Uni-Ecoloc® concrete pavers (Figure 5-7, Appendix A-6), a paving unit with a unique angular shape that is resistant to shifting under the weight of cars (Figure 5-8). Joints and bedding material will be washed # 89 stone. #89 stone is small enough to serve as a joint filler, but its pore space is large enough to readily infiltrate runoff. The depth of the base layer beneath the entire area of these diagonal parking bays will extend more than 2 feet deep (typical base courses consist of 4-6" of compacted, open-graded aggregate) . The pore space within this compacted base layer is roughly 30% of the total volume; this equates to approximately 90 cubic feet of storage capacity beneath every diagonal parking space. Runoff stored in these areas will be allowed to infiltrate into the surrounding earth.

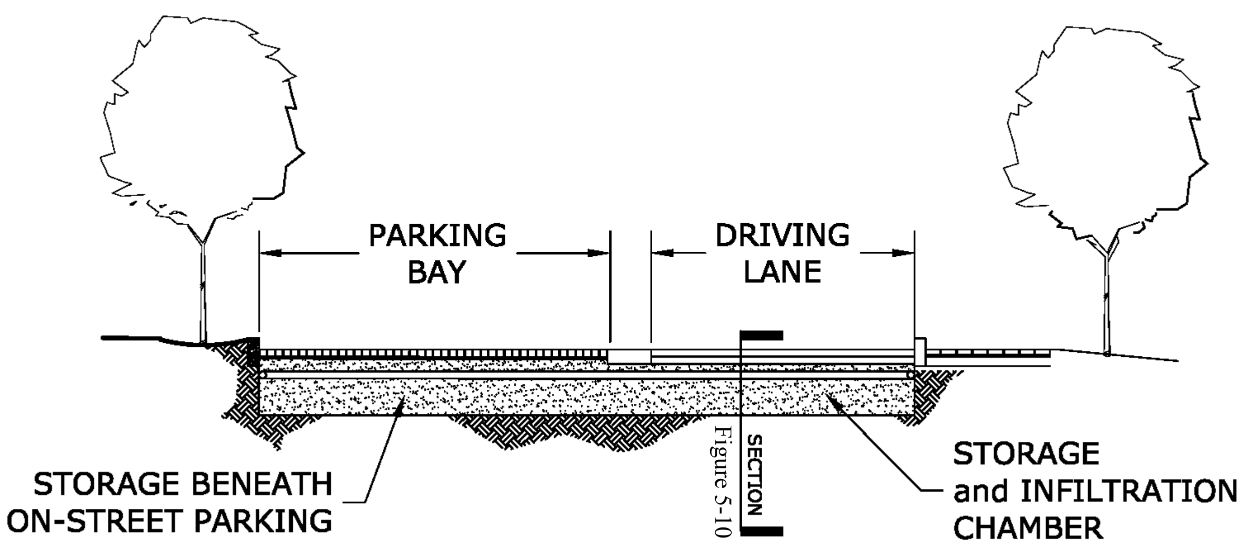


Figure 5-9: Storage beneath Parking Bays and Driving Lanes

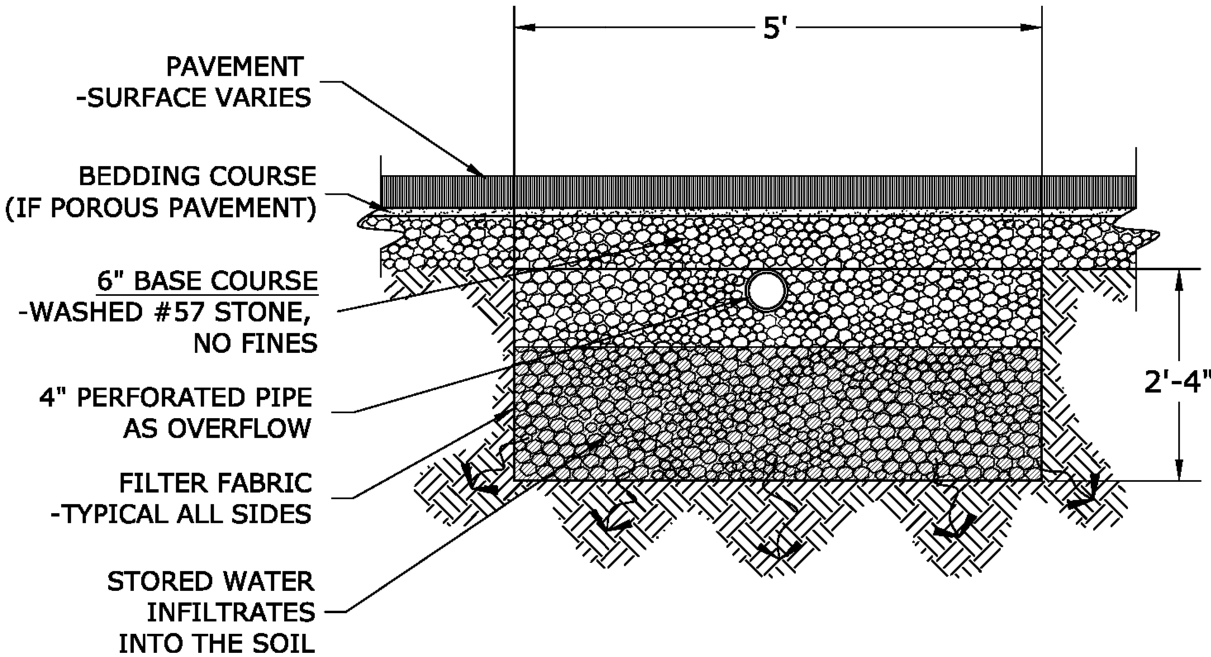


Figure 5-10: Storage and Infiltration Chamber Section

Beneath the impervious asphalt of the adjacent traveling lane is a series of storage and infiltration chambers (Figure 5-9 & 5-10). As with the treatment beneath the parking spaces, these chambers are essentially vertical extensions of the base course. Additionally, they resemble a form of modified dry well, capable of retaining and infiltrating stormwater runoff.

Base courses of the alternative landscape will be complemented by storage chambers that run perpendicular to the direction of travel, every 30’ along the length of roadway. This critical dimension was selected to coincide with the typical occurrence of street trees at Vickery (also proposed at 30’ on center). Staggering storage chambers and street trees will provide a better soil environment for the trees (less water-logged soils, greater availability of oxygen) which will in turn lead to more productive growth and overall health.

Compacted aggregate within the chambers is washed #57 stone. To reiterate, compacted base courses of such material possess approximately 30% void space. The void space within these chambers is where stormwater runoff will temporarily reside and gradually infiltrate into the ground beneath. A small corrugated pipe that runs the length of the chamber will serve as an overflow should the chamber fill to capacity. This overflow will either tie into adjacent storage areas under nearby parking bays or will lead downhill to the next chamber in the system.

The storage chamber is a logical and effective method of detention at Vickery for several reasons:

1. It can be used in many situations. Anywhere a roadway exists, these storage chambers may exist and function as well. Storage chambers at regular intervals satisfy the need to manage stormwater near its point of contact with the earth. Since they are located at frequent, regular intervals, each receives runoff from the immediate surrounding area. Because they are connected as a system, they work together to share the burden.
2. It is small. The fact that these are relatively small facilities means that they can be incorporated regularly into a variety of situations. Their size enables them to be easily dug using a 5' wide backhoe bucket. This small structure, repeated many times, can do significant work.
3. It uses simple materials. #57 stone is common, readily available and relatively inexpensive.
4. It will not interfere with utilities. Possessing a depth of only 3'+/-, storage chambers will not venture into the realm of water or sewer lines which typically sit 4' below finished grades.

It should be noted that other subsurface detention methods are also available. For example, large corrugated culverts encompassed in screened gravel can serve the same purpose as the proposed storage chambers.

Between the 2 lanes of this central avenue exists a formal green. This small piece of open space has a sidewalk around its periphery, and a plaza at its southern end. Pavement for these surfaces will match that proposed for the primary sidewalks of the Village Center; SF Rima™ porous pavers. The vegetated portion between the paved areas is approximately 160' long and 35' wide. Although this space could potentially present a significant opportunity for runoff detention, the alternative landscape will attempt to acknowledge the intended character of the formal green and propose that only a gentle depression be formed here. The low point down the center of the depression is to be only 15" below the elevation of the surrounding side-walk.

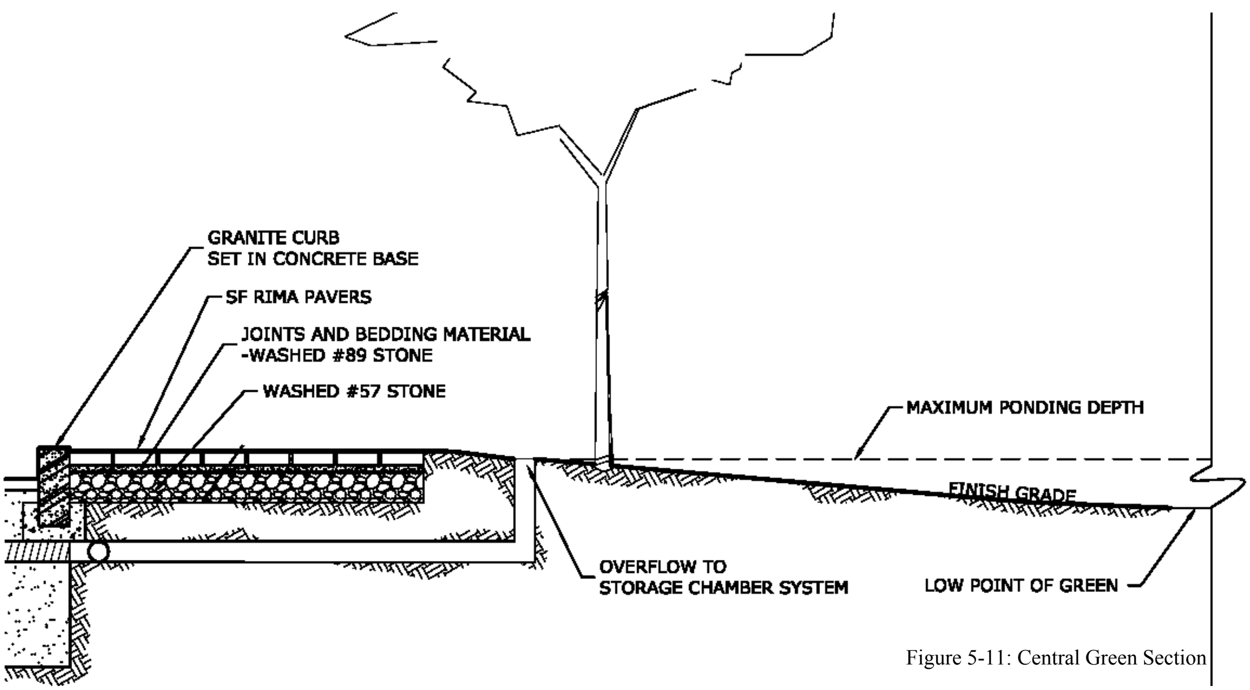


Figure 5-11: Central Green Section

There are several reasons why this space should not be carved out for greater volumes of detention. Steeper side slopes would not be easily accessible by visitors in what is supposed to be a park-like setting. Steeper side slopes would not be consistent with the vision of this space. Also, it may be important to keep this central green elevated above the level of the storage chambers under the surrounding roads. If this green were deep enough, water from the storage chambers could potentially infiltrate into it, creating an unwanted situation. Given the presumed 2% slope of the surrounding landscape and the ponding depth specified in Figure 5-11, this subtle depression will store approximately 1,000 cubic feet of runoff from impervious surfaces uphill.

Water will be directed into the area through several strategically-placed openings in the curb. These openings are multi-functional; they will provide handicap accessibility to the sidewalk and plaza around the central green as well as a path for stormwater runoff to enter the space (Figure 5-12).

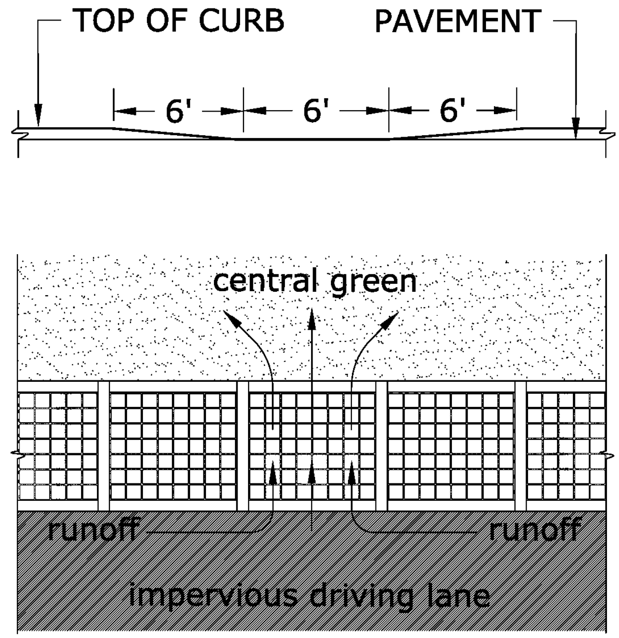


Figure 5-12: Handicap Accessible Walk

With regard to plantings, this central space should maintain a simple appearance of turf grass and a formal allee of street trees. Winged Elm (*Ulmus alata*), a tree native to this geographic region, is an excellent choice. Its mature vase-shape form makes it a perfect candidate for this prominent allee. Additionally, it is resistant to Dutch Elm Disease, a malady that has plagued the closely related American Elm.

Off-street Parking Lots:

The second feature of the alternative landscape in the T-5 Zone that will be illustrated is a typical off-street parking lot. Vickery's parking lots offer a good opportunity for reducing impervious pavements and managing stormwater. Although the driveway lanes of these lots shall be paved with impervious asphalt, parking bays will be constructed of porous pavements that possess considerable infiltration capacity. Figure 5-12 displays one of the large off-street parking areas near Vickery's Village Center.

Figure 5-13 shows a proposed section through typical portions of Vickery's off-street parking lots. Details of this section will be elaborated upon in the order that they appear, from left to right.

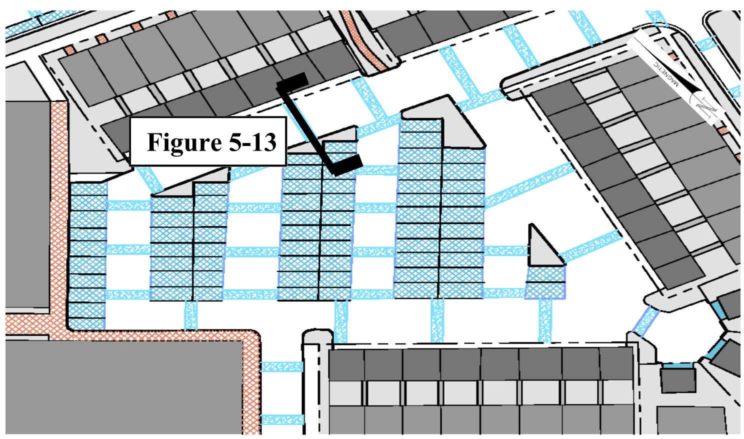


Figure 5-12: Typical Parking Lot

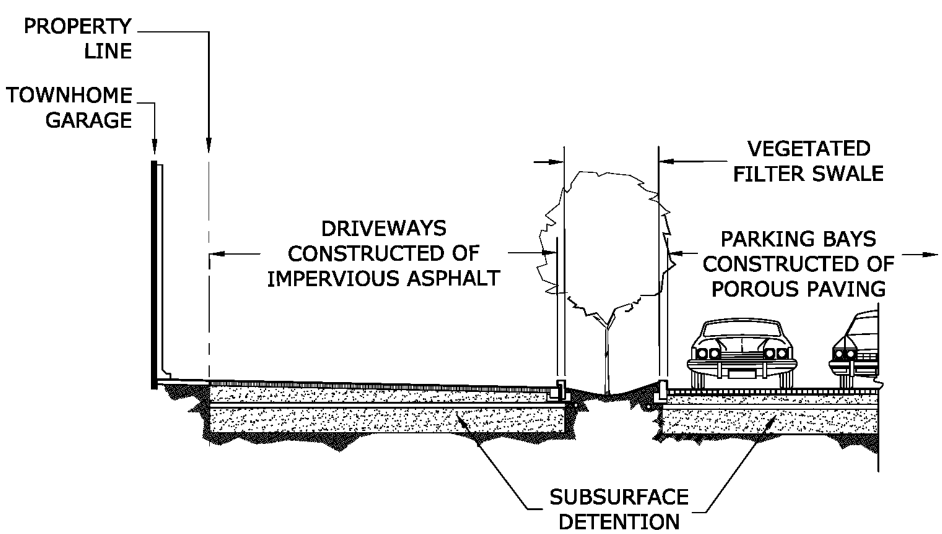


Figure 5-13: Parking Lot Section

Figure 5-14 illustrates the relationship between the building, private lot, driveway and subsurface storage system. The alternative landscape specifies that roof runoff be released directly onto pavements, instead of being tied to a storm sewer. Impervious concrete is used to construct individual driveway aprons. Driveway lanes are constructed of impervious asphalt so as to withstand heavy loads of vehicular traffic. The subsurface storage chamber, typical of that which was detailed earlier in this chapter, terminates at the property line. Storage chambers are located at 30' on center, just as they along thoroughfares. Considering the absence of trees

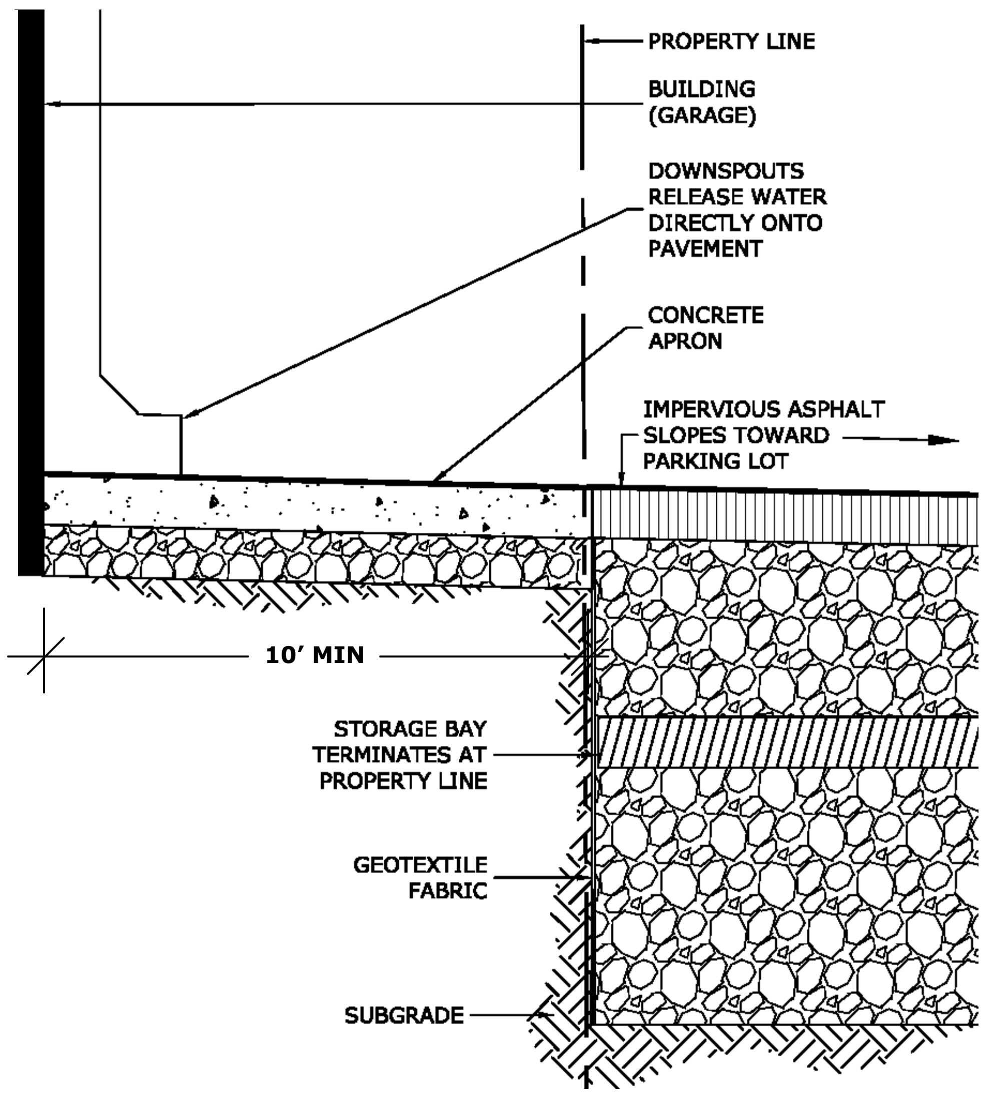


Figure 5-14: Parking Lot at Building Section

within Vickery's off-street parking lots, the spacing of these chambers could be adjusted if necessary. An alternative configuration could include chambers that coincide with the downspouts of townhomes.

Several unpaved islands are proposed within the middle of the parking lot. The alternative landscape design will utilize these in conjunction with the previously described system of storage chambers to manage the quantity and quality of stormwater generated from surrounding buildings and pavements. Figures 5-15 and 5-16 illustrate the manner in which parking lots will function with adjacent impervious pavements. Figure 5-15 shows the typical location of a curb inlet in conjunction with a storage chamber. Figure 5-16 shows how runoff from the impervious pavement may enter the vegetated parking lot island. A 2' wide opening in the curb allows runoff into the swale-formed island. A layer of river rock at the throat of the opening

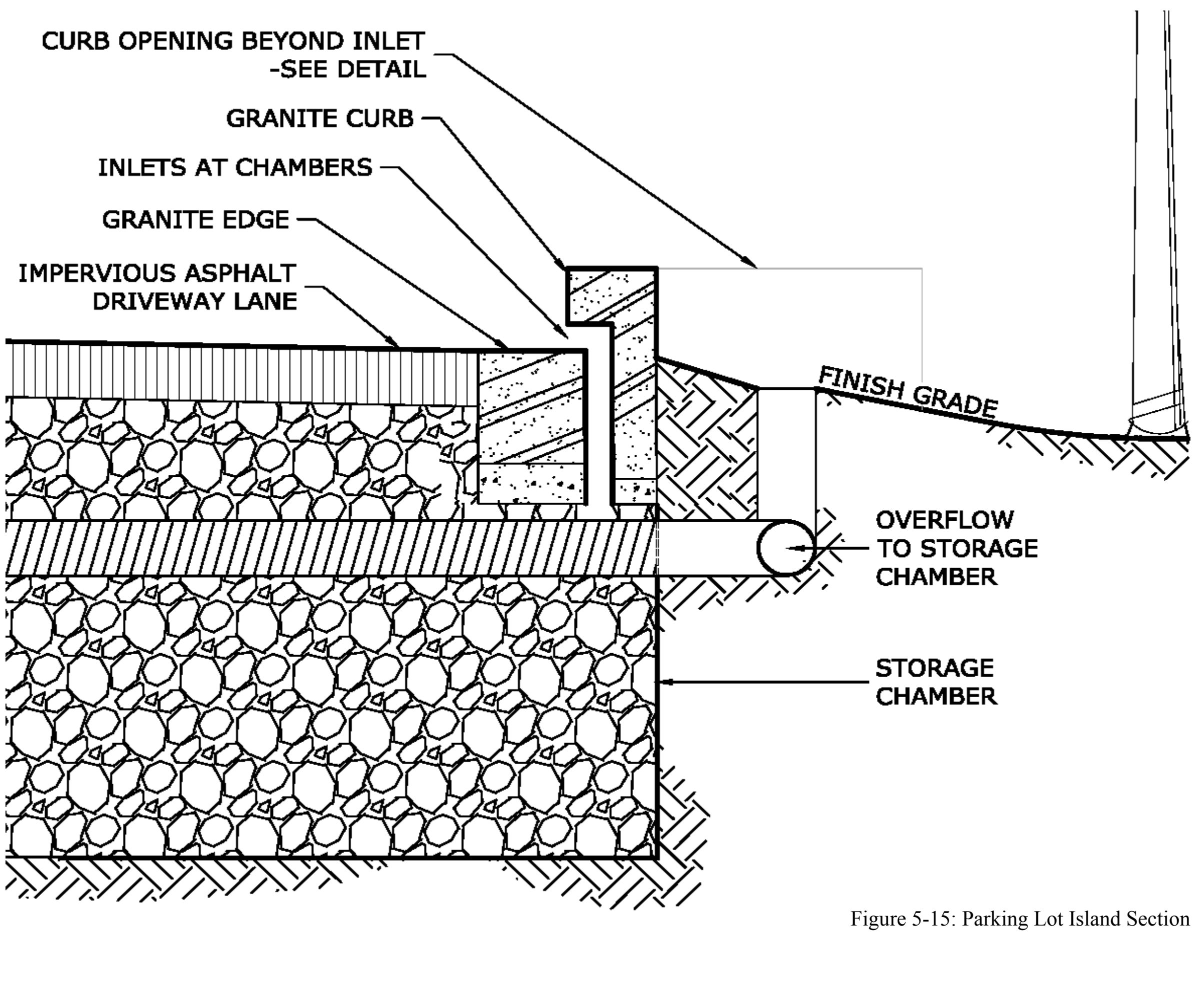


Figure 5-15: Parking Lot Island Section

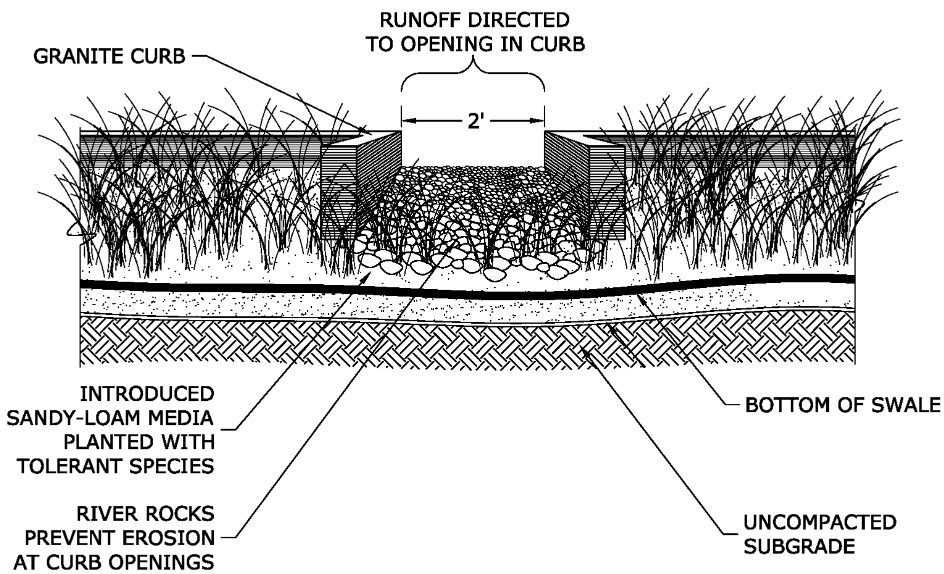


Figure 5-16: Curb Opening in Parking Lot Island

prevents runoff from eroding the bank. The low point of a typical parking lot island swale should be approximately 12" below the surrounding pavements. These will not provide substantial storage capacity, but will serve to accommodate the first flush of small rain events (under an inch).

Parking lot islands will be densely planted with large-canopy and understory trees, and ground covers; the plant palette of the alternative landscape consists of plants that are native to the southeast. Plants and trees used for this purpose must be very tolerant to adverse growing conditions; they must be able to survive periods of temporary inundation as well as periods of drought. Recommended tree species include *Platanus occidentalis, Liriodendron tulipifera, Carpinus caroliniana, Betula nigra* and *Acer rubrum*. Recommended groundcover species include, *Panicum virgatum* 'Shenandoah', *Muhlenbergia capillaris*, and *Chasmanthium latifolium*. With regard to parking lot islands, tolerance, survival, establishment and function are primary initiatives; variety and ornamentation are secondary.

The alternative landscape will utilize porous pavement in all off-street parking bays. Figure 5-17 shows a typical section through an off-street parking bay. Ecoloc pavers, the same as those used for on-street parking areas will be utilized in these off-street parking areas as well. Depth of the storage area beneath the parking bays is 24" below the perforated overflow. The length of an individual parking space, and associated storage area directly beneath is 20'. The width of the storage area will be determined by the number of spaces. Typical maximum slopes

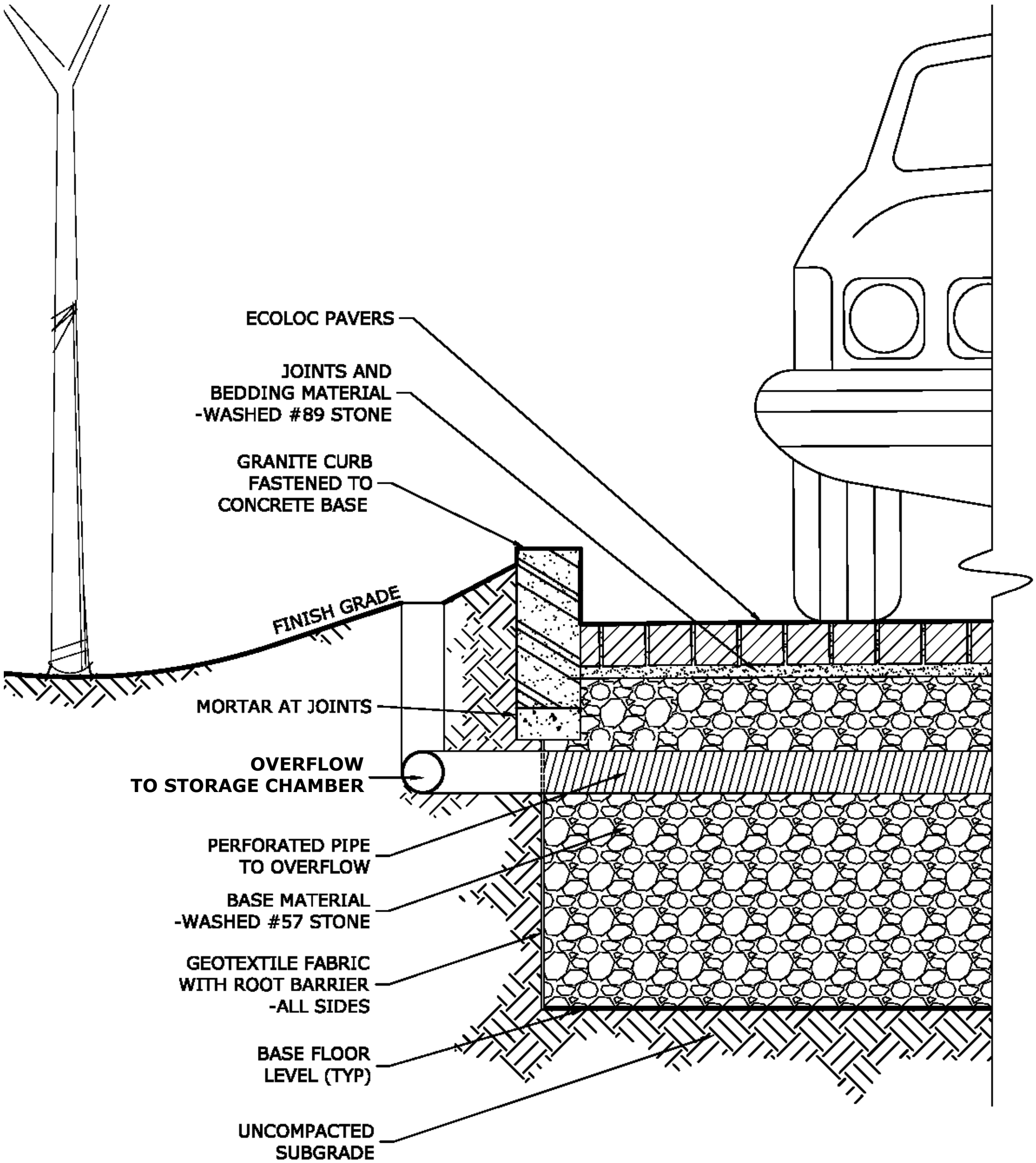


Figure 5-17: Parking Lot Storage Bay Section

recommended for parking lots are 5%. Although the predevelopment contours of this area reveal slopes of 10% or greater in this area, it will be presumed that the parking lot viewed here slopes down toward the south at a maximum of 5%. Figure 5-18 shows a series of terraced storage bays that can accommodate a 5% slope. In this system, one 18' wide storage bay exists for every three parking spaces (Figure 5-19); this method equates to storage capacity under approximately 2/3 of the total parking bay area. Storage bays maintain the same depth as the storage chamber detailed earlier in the chapter (24"). As with the storage chambers, one can expect 30% of the volume within the compacted aggregate of these bays to exist as void space. Given these numbers, the potential storage capacity of the bays underneath the 247 off-street parking spaces associated with the Village Center is approximately 17,874 cubic feet. These bays contribute significant storage space where it is needed, in the relatively dense and impervious Village Center.

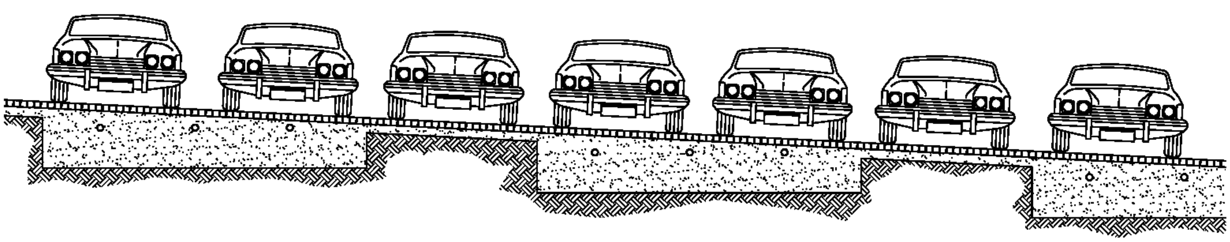


Figure 5-18: Terraced Storage Bay Profile under Parking Lot

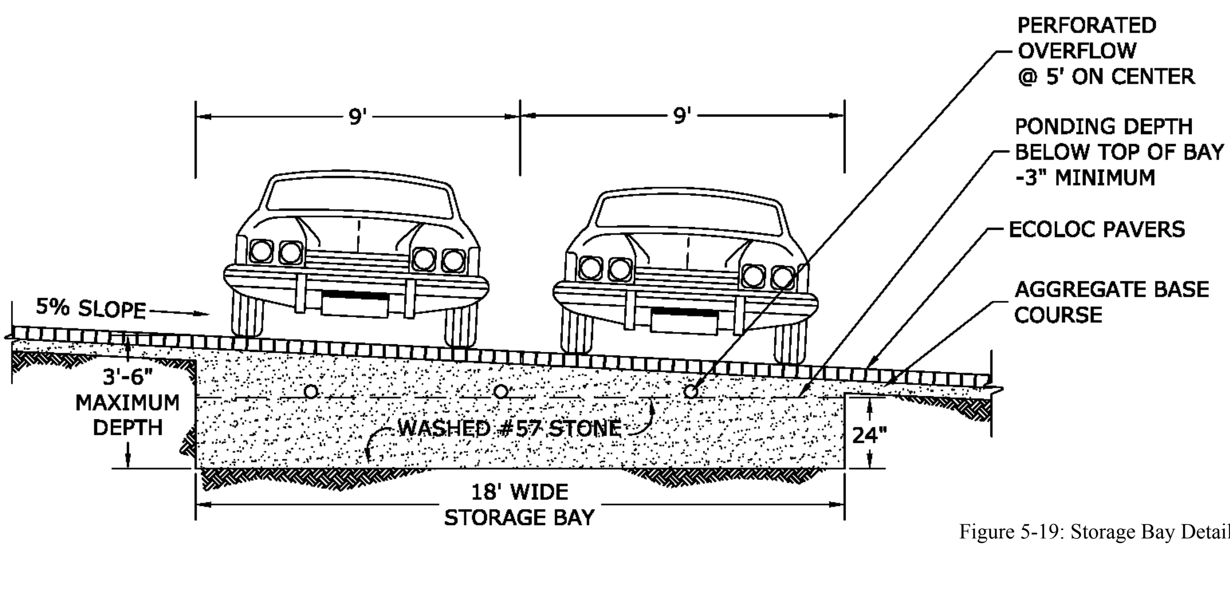


Figure 5-19: Storage Bay Detail

Street:

The third area within this first site-specific plan to be addressed by the alternative landscape is the street and its associated landscape (Figure 5-20). Figure 5-21 presents a cross-section through a typical street. Important components will be covered from left to right as they appear in this section.

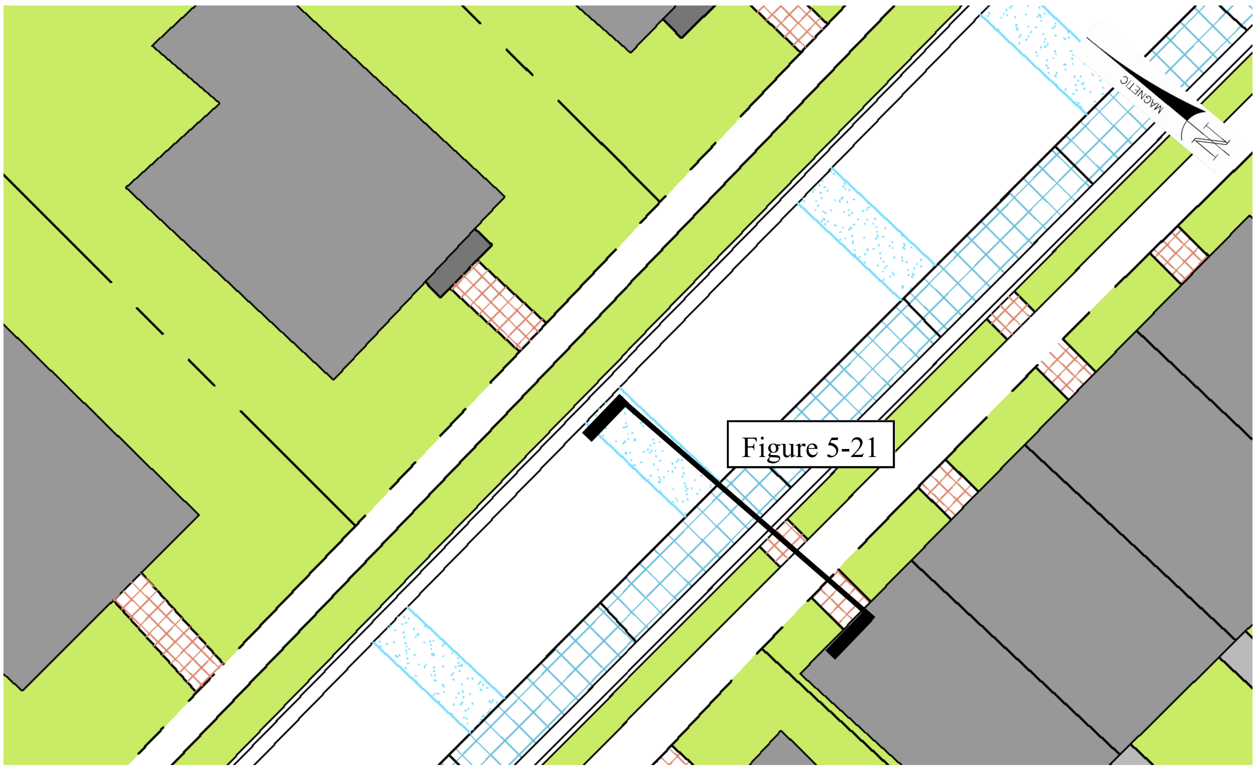


Figure 5-20: Typical Street

Prescribed building setbacks along streets typically range from 12’ to 24’, although front porches are intended to extend into this space by a minimum of 8’. These dimensions result in fairly small front yards, ranging from 4’ to 16’. This considered, front yards of residences along streets will not be utilized for detention. Runoff in these spaces must simply be directed toward the street where it will be managed by the system of planting swales and storage chambers.

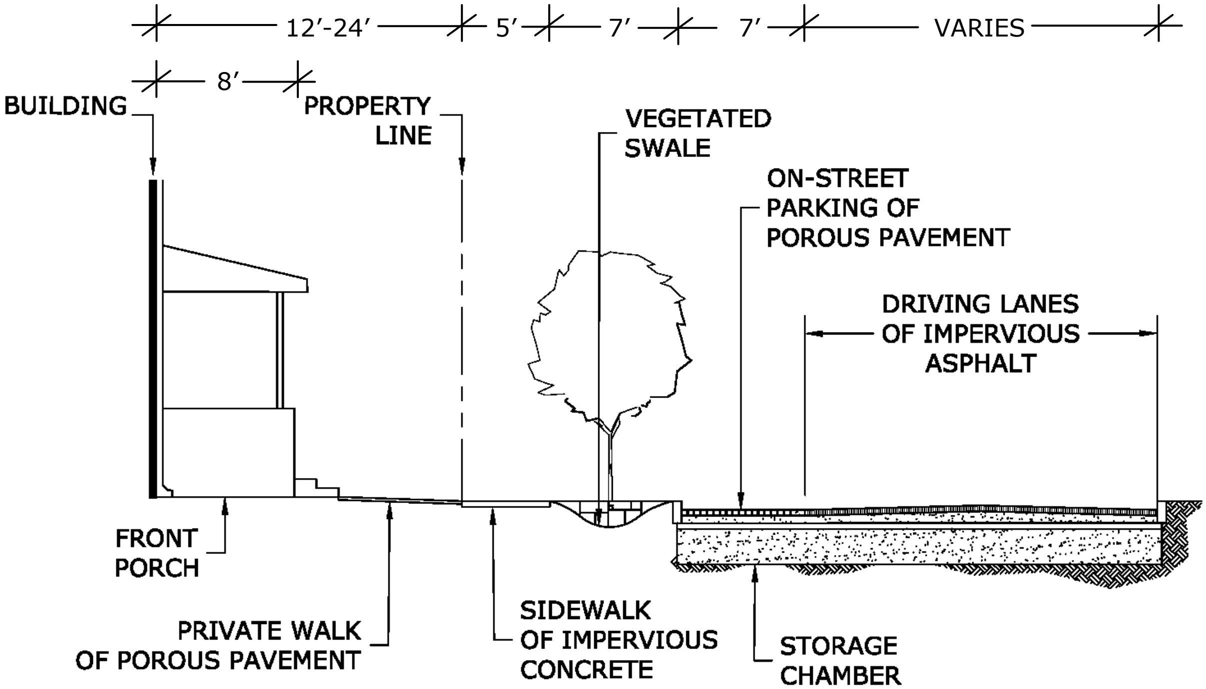


Figure 5-21: Typical Street Section

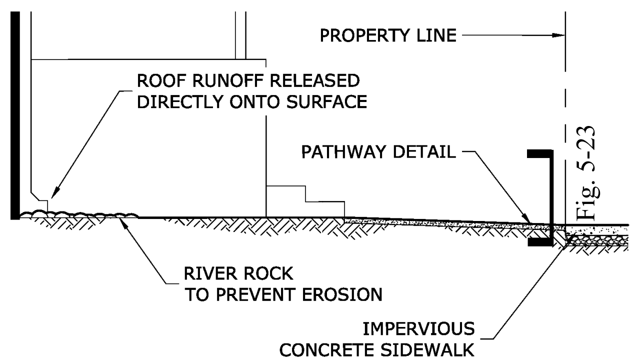


Figure 5-22: The Building at the Street

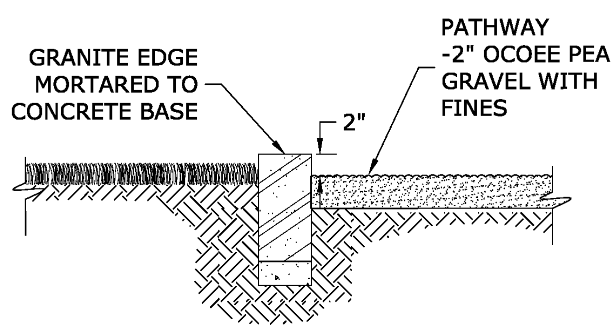


Figure 5-23: Private Walk Treatment

With regard to roof runoff, the alternative landscape specifies that downspouts be released directly onto the ground surface (Figure 5-22). Private walks that extend from residences toward the street should be constructed of porous materials. Because DPZ & Co. did not specify the material of these walks, it was presumed that they were to be built of impervious concrete. Replacing these materials with porous ones for all private walks will make a significant contribution toward the reduction of total impervious coverage. Although the alternative landscape specifies a consolidated aggregate for these private walks (Figure 5-23), other forms of porous pavement will be also be permitted for this use. Public sidewalks within the right-of-way will typically be constructed of impervious concrete.

Figure 5-24 displays a typical planting swale associated with a street in the alternative landscape. Elevated walkways, bordered by small retaining walls, will serve as intermittent weirs along planting swales (Figure 5-25). These will enable terraced levels of microretention

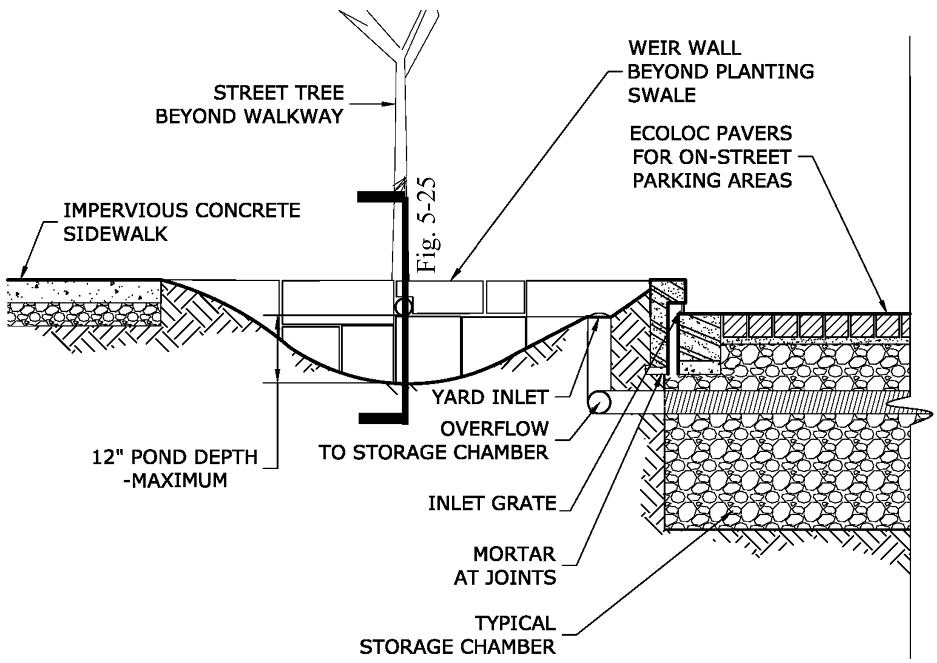


Figure 5-24: On-street parking and Planting Swale of a Street

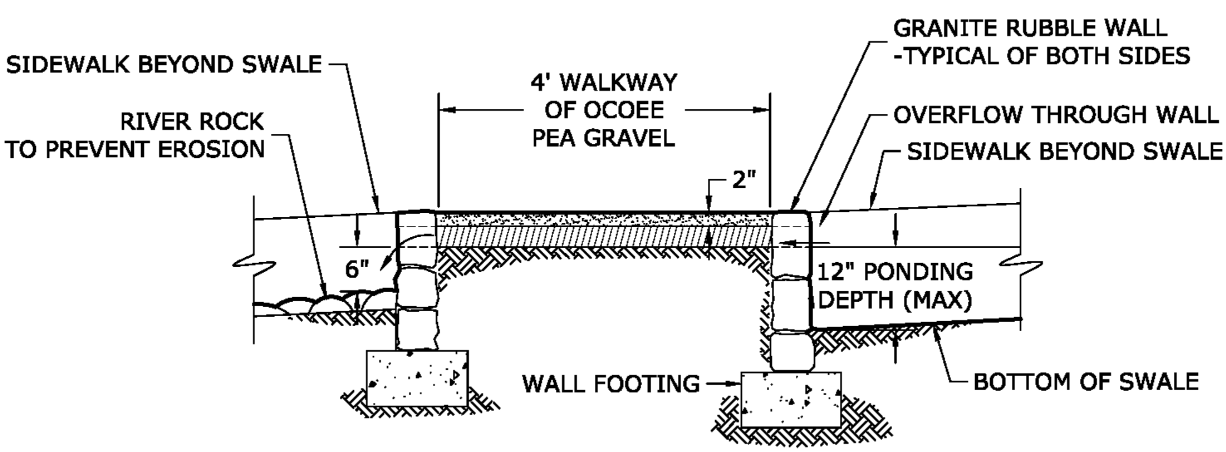


Figure 5-25: Weir Wall Section

within swales that occur on slopes. Although individual planting swales do not possess great volume capacity, the consistent use of them throughout the development will have a notable effect. Utilizing this method of microretention, planting swales on slopes of 5% or less will be assumed to possess an average of 50 cubic feet of storage capacity, while swales on roads with a 6% or greater slope will be assumed to possess an average of 25 cubic feet of storage capacity. Planting swales should preferably be heavily planted with a tolerant collection of street trees and groundcovers. The suggested plant list for off-street parking lot islands is an appropriate list for planting swales as well.

Adjacent to the planting swale is shown the on-street parking treatment typical of an alternative landscape street. Paving units identical to what was proposed in the Village Center are used for these areas as well. A 24" deep base layer, identical to what was proposed beneath the diagonal parking spaces of the avenue, will also be utilized under these on-street parking spaces. Subsurface storage within the pore space of these on-street parking areas averages approximately 100 cubic feet of storage per parking space. Additionally, the storage under these parking spaces is connected with the system of chambers that is proposed throughout Vickery; Storage chambers are proposed at 30' on center along all streets to coincide with the proposed spacing of street trees (also at 30' on center). Staggering storage chambers and street trees will create a preferable soil climate for street trees.

__Site Specific Plan #2: T-4 Zone__

The second site-specific plan will be used to illustrate a typical landscape associated with a road (Figure 5-26). Figure 5-27 displays a cross-section through a typical road and associated components of the alternative landscape. Details of the section will be elaborated upon as they appear from left to right.

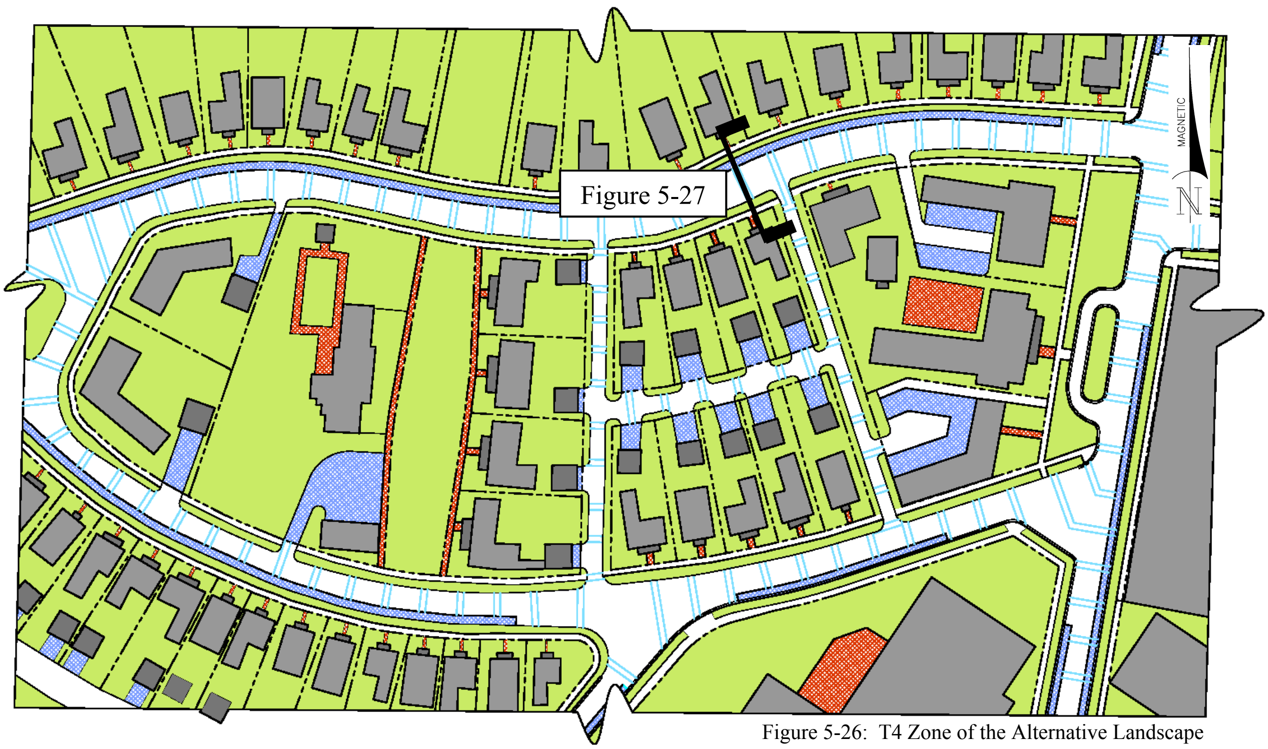


Figure 5-26: T4 Zone of the Alternative Landscape

Typical building setbacks along roads range from 12' to 24'. Front porches, typical of new urbanist residences are intended to extend into these setbacks by a minimum of 8'. The treatment of front yards in the alternative landscape is virtually identical to what was proposed for residences along streets. Small front yards will not be utilized for detention. Foundation plantings, ornamental trees and turf areas will compose the typical landscape. Runoff from roofs should be released directly onto the surface and directed toward the road. Private walks that connect front porches to public sidewalks should be constructed of porous materials; the detail given in the previous section is appropriate for these walks as well.

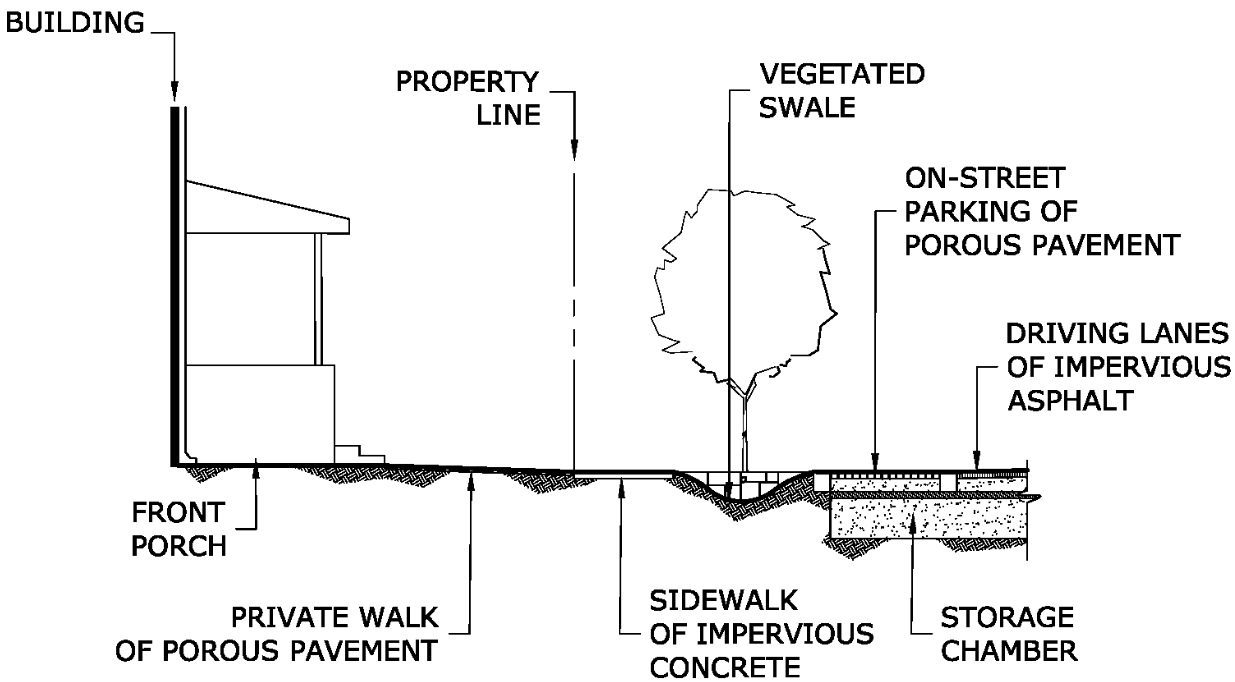


Figure 5-27: Typical Road Section and Associated Landscape

Planting swales along roadways will be identical to the standards set for streets. Intermittent weir walls that serve to elevate residential walkways will interrupt the swales, allowing for small, yet frequent areas of microretention. As with the planting swales of streets, these should be densely planted with the native trees, shrubs and grasses that were specified for parking lot islands in the earlier section of this chapter.

Roads, which generally comprise the more “rural” of Vickery’s corridors, do not utilize curb and gutter (Vickery Charrette Book, p35-38). Figure 5-27 shows this uninterrupted connection of the vehicular pavement with the adjacent landscape. Ecoloc pavers will be used for all designated parking along roads. As with streets, storage chambers are located at 30’ on center under all roads of Vickery. Chamber length is typically dictated by the width of pavement.

Site Specific Plan #3: T-3 Zone

Figure 5-28 is the digitized version of the third Site Specific plan; this is the relatively "suburban" area of Vickery. The secondary network of lanes are a prominent component in this plan; they provide access to all of the detached garages. Specified as 8' in width (Vickery Charrette Book, p38), these narrow vehicular corridors are assumed to be one-directional thoroughfares. DPZ & Co. specifies that these lanes may be paved with gravel so as to maintain a rural quality (reference); it will be assumed that they are constructed of compacted gravel in coverage data of Chapter Six.

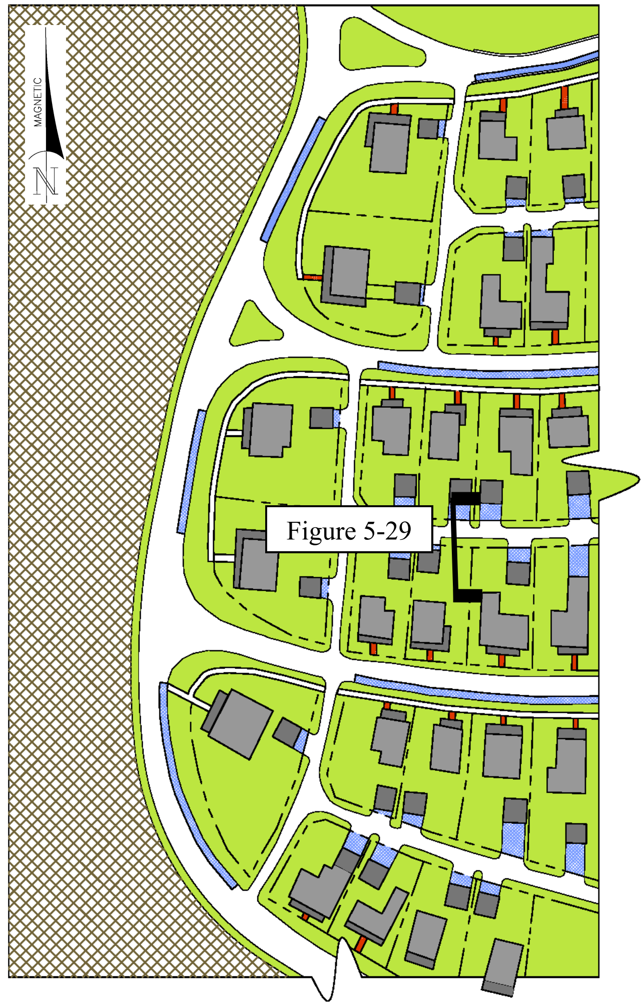


Figure 5-28: T3 Zone of Alternative Landscape

One important aspect of these rear corridors is the orientation of the garage within the property limits. Most garages shown in these plans appear to be about 20' wide. These are logically presumed to be 2-car garages. Additionally, typical rear lot widths in this portion of Vickery range from 55' to 65'. In fact, the vast majority (approximately 75%) of the single family lots at Vickery are estimated to be 45' wide or wider. These critical dimensions imply that for most single-family lots, there could theoretically exist a 20' wide, uninterrupted portion of landscape that could exist along the rear property line. This is an important number, because utility easements, such as drainage easements are typically 20’ in width. In other words, the prescribed layout of these lots and buildings would appear to accommodate drainage easements if they are required for any reason by a given municipality. Microretention or storage structures in the backyards of private lots could feasibly be permitted since enough space exists between lot lines and buildings to link these areas with the primary system within the adjacent lane’s right-of-way.

Figure 5-29 shows a cross-section through a typical lane and its associated landscape. Primary elements will be detailed in the order that they appear from left to right in this section. Rear setbacks of Vickery range from 3’ to 6’ (minimum). The alternative landscape specifies that runoff from backyards and garages be directed toward the lanes in the rear. Individual driveways, aprons and driving lanes within the right-of-way can be constructed according to the detail in Figure 5-30. Drainage swales associated with lanes will be identical in dimension to those specified for streets and roads. Instead of walks, driveways will frequently interrupt these swales, allowing for small yet frequent areas of microretention. Retaining walls (weir walls) are not proposed for the edges of driveways.

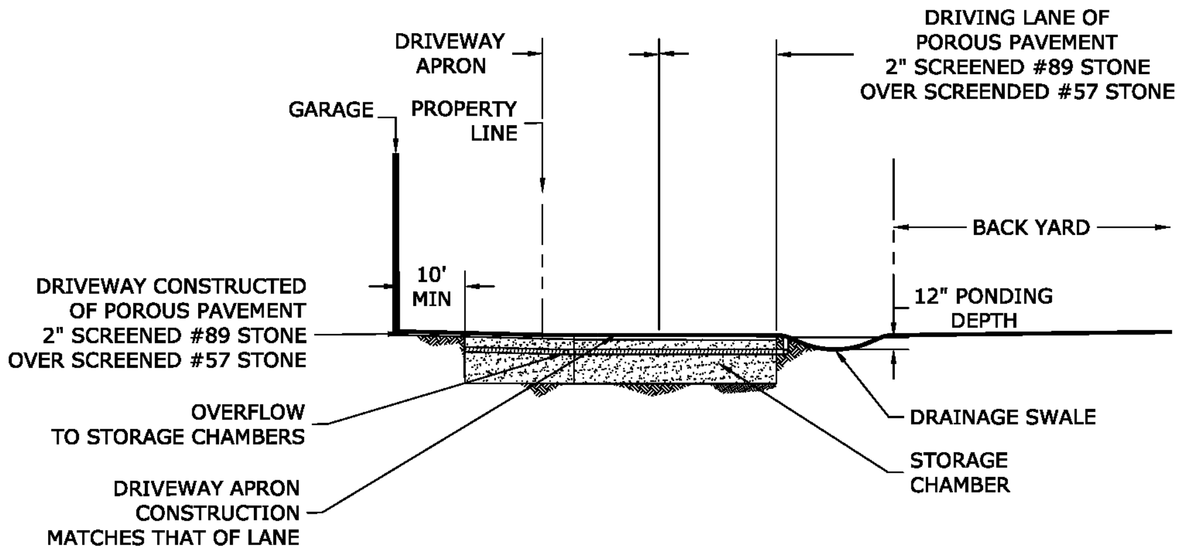


Figure 5-29: Typical Lane and Associated Landscape

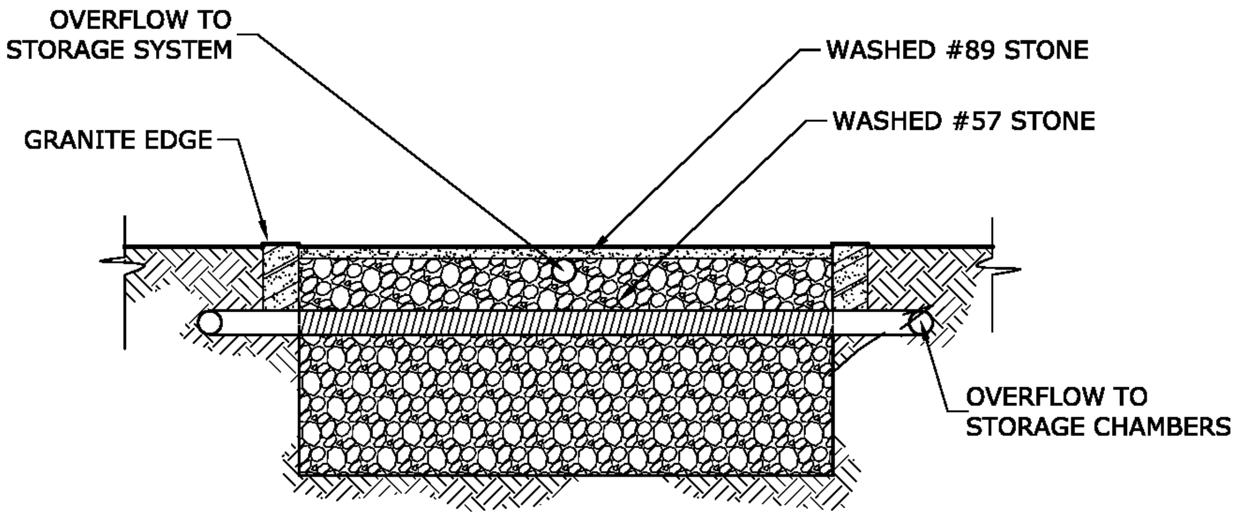


Figure 5-30: Typical Driveway Detail

In contrast to the front yards, the back and side yards of most single-family lots offer adequate space to incorporate significant vegetation in the landscape. As was mentioned at the beginning of the chapter, one of the primary initiatives of the alternative landscape's Stormwater Management Plan is to increase canopy coverage throughout Vickery. Therefore the alternative landscape will set minimum canopy coverage requirements for single-family lots that may be accomplished through the dense planting of trees within these side and rear yards.

All single-family lots will be required to achieve 50% canopy coverage of their individual lot within a period of 10 years. Tree populations will consist of 30% large- and medium-canopied trees, 30% evergreen species and 40% understory trees. Recommended species are listed in Appendix A-5. It is presumed that some existing trees of the predevelopment site were intended to be saved through construction; Figure 4-13, for example, displays several large-canopy trees amidst the proposed development. Rigorous protection of the entire root zone of these trees should be maintained during all periods of construction to insure survival and longevity; the environmental and aesthetic benefits of these mature specimens is certainly outweigh the challenges of protecting them during construction.

CHAPTER 6: FINDINGS AND CONCLUSIONS

The alternative landscape attempted to manage stormwater by retaining it close to its point of contact and allowing it to infiltrate into the soil. This philosophy of management was conducted using several methods. Porous pavements were incorporated to reduce impervious coverage and to allow stormwater more opportunity to come into contact with the soil. Microretention areas that are capable of storing small volumes of runoff were specified for areas such as the central green and planting swales. A subsurface system of storage chambers and bays was proposed within the base layer of pavements to retain volumes of stormwater runoff. Minimum canopy coverage requirements were established for Vickery to utilize vegetation for the interception of rainfall and the conditioning of soils.

The altered stormwater function of the alternative landscape will be generalized in terms of a resulting Curve Number (CN). The SCS curve number method is used to determine the volume of runoff from a given area following a rain event. The SCS method embodies a number of soil conditions and coverage types to assign a runoff factor, or curve number, for a given area. The equation for the SCS method is as follows (Georgia Stormwater Manual, 2-1.18):

$$Q = \frac{(P-I_a)^2}{(P-I_a) + S}$$

Q = runoff (in.)
P = rainfall (in.)
S = potential maximum retention after runoff begins (in.)
I_a = Initial abstractions (in.)
i.e. loss of precipitation to infiltration and surface depressions before runoff begins.

Additional storage proposed in the alternative landscape, such as retention upon the surface or within the base layer of pavements, will be factored as additional S because it is a quantity that is stored above the existing soil. This additional storage is not considered I_a (Initial Abstraction) because the infiltration capacity of the soil is not altered. A Curve Number can be defined in terms of S:

$$S = \frac{1000}{CN} - 10 \qquad or \qquad CN = \frac{1000}{S+10}$$

Additional S provided in the alternative landscape can be factored into the curve number of the originally proposed development ($CN_{ORIGINAL}$) to create an adjusted curve number ($CN_{ALTERNATIVE}$) as follows:

$$CN_{ORIGINAL} = \frac{1000}{(S_{ORIGINAL} + 10)} \qquad or \qquad S_{ORIGINAL} = \frac{1000}{CN_{ORIGINAL}} - 10$$

And therefore,

$$CN_{ALTERNATIVE} = \frac{1000}{(S_{ORIGINAL} + S_{ALTERNATIVE} + 10)}$$

The altered stormwater function of the alternative landscape will be evaluated by comparing this adjusted composite Curve Number ($CN_{ALTERNATIVE}$) with the composite CN of the originally proposed development ($CN_{ORIGINAL}$). The pre-developed curve number for the site ($CN_{PREDEVELOP}$) will also be given so that further comparisons can be made.

Table 6-1 presents coverage data and a resulting Curve Number of 59.19 for the pre-developed site. The information in this table was covered in Chapter Five. Table 6-2 shows the calculation for the predevelopment S value.

Table 6-1: Determination of Predevelopment Site Curve Number for Developed Area (148.50 Acres)

PREDEVELOPMENT SITE HYDROLOGIC SOIL GROUP B					
	AREA (FT^2)	**ACRES**	**% of total (148.50 acres)**	**CN**	**WEIGHTED CN**
WOODLAND	3,096,056	71.08	47.86%	55	26.32
GRASSLAND	3,150,000	72.31	48.70%	61	29.70
BUILDINGS	117,000	2.69	1.81%	98	1.77
THOROUGHFARES (GRAVEL)	105,500	2.42	1.63%	85	1.39
TOTAL	6,468,556	**148.50**	**100%**		**59.19**

Table 6-2: Determination of Predevelopment Site S value for Developed Areas (148.50 Acres

$$S_{PREDEVELOP} = \frac{1000}{CN_{PREDEVELOP}} - 10 \qquad S_{PREDEVELOP} = \frac{1000}{59.19} - 10$$

$$S_{PREDEVELOP} = 6.89$$

66.25 acres of "woodland" was not represented in Table 6-1. This is the area that corresponds with the 66.25 acres of "open space outside of the development zone" that will also not be included in coverage data for the original site and the alternative landscape. It was noted in Chapter Five that this undeveloped area of open space is an arbitrary number that may skew results of these findings; for this reason, the area was omitted from the coverage calculations of the Predevelopment Site, the Original Site and the Alternative Landscape. Appendix A-2, A-3 and A-4 presents data for all three scenarios that includes the complete square footage of open space both within and outside of the development zone (214.75 total acres).

Table 6-3: Determination of Original Plan Curve Number for Developed Areas (148.50 Acres)

ORIGINAL MASTER PLAN HYDROLOGIC SOIL GROUP B					
	AREA (FT^2)	ACRES	% of total (148.50	CN	WEIGHTED CN
THOROUGHFARES					
TOTAL	1,075,690	24.69	16.63%		
IMPERVIOUS	859,810	19.74	13.29%	98	13.03
GRAVEL	215,880	4.96	3.34%	85	2.84
PARKING					
TOTAL	120,000	2.75	1.86%		
IMPERVIOUS	120,000	2.75	1.86%	98	1.82
BUILDINGS					
TOTAL	1,088,775	24.99	16.83%		
COMMERCIAL	118,000	2.71	1.82%	98	1.79
RESIDENTIAL	740,225	16.99	11.44%	98	11.21
GARAGES	230,550	5.29	3.56%	98	3.49
WALKS					
TOTAL	332,900	7.64	5.15%		
IMPERVIOUS	332,900	7.64	5.15%	98	5.04
VEGETATED AREAS	3,164,945	72.66	48.93%	69	33.76
OPEN SPACE					
TOTAL	686,350	15.76	10.61%		
IN DEVELOPMENT ZONE	686,350	15.76	10.61%	61	6.47
TOTAL	6,468,660	**148.50**	**100%**		**79.45**

Table 6-3 presents coverage data and a resulting curve number of 79.45 for the originally planned development of Vickery. Table 6-4 shows calculations for the S value of the originally planned development.

Table 6-4: Determination of Original Plan S Value for Developed Areas (148.50 Acres)

$$S_{ORIGINAL} = \frac{1000}{CN_{ORIGINAL}} - 10 \qquad S_{ORIGINAL} = \frac{1000}{79.45} - 10$$

$$S_{ORIGINAL} = 2.59$$

The coverage data in Table 6-3 was derived from a combination of DPZ & Co. plans, minimum guidelines and specifications. CN values were derived from the Georgia Stormwater Manual (2.1-22). Information was generated as follows:

1. Thoroughfares. Center lines of thoroughfares were digitized from DPZ & Co. plans to determine linear footage. Thoroughfare sectional dimensions were specified by DPZ & Co. (Vickery Charrette Book, p32). Square footage of thoroughfares was calculated using specified dimensions in conjunction with digitized linear footage. This method was used instead of straight digitization due to the illustrative nature of DPZ & Co. drawings. Unless otherwise specified, thoroughfares were presumed to be constructed of impervious asphalt. DPZ & Co. specifications did encourage lanes (alleys) to be constructed with gravel, but did not detail the manner of construction. Gravel lanes were therefore presumed to be compacted with fine particles and relatively impervious.
2. Thoroughfare counts include private driveway areas (ft^2). Driveways were digitized from DPZ & Co. plans and estimated for portions of the site not shown. Driveways were presumed to be constructed of compacted gravel, unless otherwise stated, due to their close proximity to lanes (alleys), also constructed of gravel.
3. Thoroughfare counts include on-street parking areas (ft^2). On-street parking lanes were specified within the various thoroughfare types.
4. Parking. "Parking" refers to off-street parking lots. These areas were digitized from DPZ & Co. plans. The actual parking stalls of several smaller office lots (T5 Plan) were not illustrated, and were thus estimated by the author based on the provided layout and dimensions.

5. Buildings. Commercial, civic and attached, multi-family housing buildings were digitized from DPZ & Co. plans. Some single family homes were also digitized from DPZ & Co. site specific plans. The remainder of the lots and building areas were estimated using available plans as examples. DPZ & Co. specifications called for 475 single-family lots at Vickery. The estimated distribution of homes is as follows:

    - 25% of single-family homes were estimated to occur on lots ranging from 30' to 45' wide. These homes averaged 1,100 square feet including front porches.
    - 50% of single-family homes were estimated to occur on lots ranging from 46' to 55' wide. These homes averaged 1,425 square feet including front porches.
    - 25% of single-family homes were estimated to occur on lots greater than 55' in width. These homes averaged 2,000 square feet including front porches.

   Garages were typically portrayed in DPZ & Co. drawings as 2-car garages of about 450 ft^2. This number was applied to garages of all single family homes. Garages of attached housing in T5 zone were digitized.

6. Walks. Specified walkways were included in road specifications by DPZ & Co. Private walks were not typically shown, and were therefore estimated throughout the site.

7. Vegetation Areas. This section includes all non-paved areas that were not specified as open space. The CN used for this category was "open space in fair condition."

8. Open Space. Areas of open space were delineated by DPZ & Co. (Vickery Charrette Book, p27). If large trees were represented within these areas, it was assumed that these were existing trees that were to be saved through construction. Likewise, open space with little or no trees represented was assumed to areas of mass grading. Open space is identified as "in the development zone" or "outside of the development zone." Open space in the development zone will be used to calculate Curve Numbers and S Values for the predevelopment

site, the originally planned development and the alternative landscape. The CN used was that for "Range land in Good Condition."

Table 6-5 presents the calculation for determining the retention volume of the alternative landscape. Table 6-6 shows the calculation to determine the S value of the alternative landscape. Table 6-7 displays the calculation for the alternative landscape Curve Number.

Calculations that include open space outside of the development zone can be found in Appendices A-2 through A-4.

Table 6-5: Determination of Alternative Landscape Retention Volume

RETENTION VOLUME OF THE ALTERNATIVE LANDSCAPE			
METHOD	**QUANTITY**	**UNITS**	**TOTAL ft^3**
Storage Chambers	27,739 linear feet	3 ft^3 per l.f.	83,217 ft^3
Storage Bays	3,310 linear feet	5.4 ft^3 per l.f.	17,874 ft^3
On-Street Parking	15,000 linear feet	4.2 ft^3 per l.f.	63,000 ft^3
Central Green	1	1,000 ft^3	1,000 ft^3
Planting Swales			
Roads ≤ 5%	475 swales	50 ft^3 per swale (avg.)	23,750 ft^3
Roads ≥ 6%	475 swales	25 ft^3 per swale (avg.)	11,875 ft^3
TOTAL			**200,716 ft^3**

Table 6-6: Determination of Alternative Landscape S Value

DETERMINATION OF $S_{ALTERNATIVE}$			
Stored (ft^3)	200,716 ft^3		
(divided by total area)	6,468,660 ft^2		
$S_{ALTERNATIVE}$ =	**0.031 feet**	*or*	**0.372 inches**

The following formula is used to calculate $CN_{ALTERNATIVE}$ using calculated S values for the original and alternative landscapes (Tables 6-4 and 6-6):

Table 6-7: Determination of Alternative Landscape Curve Number for Developed Areas (148.50 Acres)

$$CN_{ALTERNATIVE} = \frac{1000}{(S_{ORIGINAL} + S_{ALTERNATIVE} + 10)}$$

$$CN_{ALTERNATIVE} = \frac{1000}{(2.59 + .372 + 10)} \quad \textit{therefore,} \quad CN_{ALTERNATIVE} = 77.15$$

Conclusions:

A comparison of the Curve Numbers and S Values of the Predevelopment Site, the Originally Planned Development and the Alternative Landscape shown in Table 6-8. These numbers relate to the area within the development zone (148.50 acres).

Table 6-8: Comparison of Curve Numbers and S Values

$CN_{PREDEVELOP} = 59.19$	$S_{PREDEVELOP} = 6.89$
$CN_{ORIGINAL} = 79.45$	$S_{ORIGINAL} = 2.59$
$CN_{ALTERNATIVE} = 77.15$	$S_{ALTERNATIVE} = 2.96$

The alternative landscape design for Vickery exhibited mixed results. A 14.28% increase of S is arguably a significant increase in the storage capacity of this landscape when compared with that of the original plan. However, a decrease of approximately 2.8% in the Curve Number value does not appear very significant. Curve numbers of the original plan and alternative landscape indicate that both sites produce significantly more stormwater runoff than was generated from the predevelopment site.

Certain aspects of the alternative landscape design worked well to manage stormwater within this new urbanist development; other components may be improved. It is difficult to make an absolute determination of the design's success or failure given the fact that no specific target volume of retention or CN was set. Data indicated that the alternative landscape was able to limit runoff more so than the originally proposed development. However, the additional S value brings into question the alternative landscape's success in retaining significant volumes of runoff from larger storms. It is appropriate to examine both the pros and cons of this design so that further work may continue to yield improved results.

The alternative landscape succeeded in retaining stormwater within the given constraints of the proposed development. No buildings, roads or walks were moved or eliminated in the process. Stormwater management utilized resources efficiently within the development's structures and layout.

The alternative landscape design was able to achieve approximately 1/3" of retention over the 148.50 acre developed site. In doing so, it essentially provided a volume of storage capacity that is comparable to a large detention basin (200,716 ft^3); this volume, however, was spread evenly across the entire site, rather than concentrated at one central location. Even under impervious pavements, water was allowed to infiltrate. In these terms, results of the alternative landscape are significant.

A primary achievement of the alternative landscape was the incorporation of a stormwater management system into the interconnected network of roads and parking areas. Utilizing the corridors is certainly logical. While they provide circulation for cars and pedestrians, they also can function for stormwater.

With regard to flaws associated with the alternative landscape, cost may conceivably be one. Although simple materials were used, the sheer quantity of them could make this design costly. What appears at face value to be expensive may actually be a cost effective method in the long run as an alternative to single-purpose stormwater basins.

Another issue with this design is that it may generate a large volume of fill dirt due to all of the chambers and bays required for the subsurface detention system. If grading plans for the project are closely coordinated with civil plans, and if excess fill is anticipated and planned for, it can feasibly be engineered into the overall site design.

Although the alternative landscape concentrated on physical volumes of storage, it did not specifically address the impact of the design on water quality. Due to the manner in which stormwater was managed, a presumption was made that this retention and infiltration of stormwater would have positive effects upon water quality. Velocity rates of runoff would be reduced due to the high frequency of retention areas; runoff would not have the opportunity to travel far, and thus, would not be able to attain high rates of momentum. Additionally, runoff is consistently brought into contact with soils and vegetation, helping to purify it of pollutants. The expansive aggregate reservoirs would effectively cleanse stored water of bacteria and suspended solids washed from the surface.

Some methods of retention exist that were not utilized by the alternative landscape. Water harvesting, for instance, was not incorporated into Vickery. Utilizing grey water for non-potable uses such as supplemental irrigation or thermal storage could present an entirely different facet in the pursuit of environmental design. Harvesting runoff would involve a whole new set of challenges, but could well be incorporated into a sustainable landscape. Green roofs were not considered in the alternative landscape as they do not represent typical architectural styles of new urbanist communities.

Several components of Vickery's prescribed layout proved to be inefficient or prohibitive in terms of stormwater management efforts. The first of these was the relationship between buildings. Although the close proximity of homes to one another and to the road maintains a new urbanist aesthetic, these relationships prevent opportunities in many of the front and side yards for retention of stormwater.

Secondly, the long road that runs north to south, parallel with Bentley Creek, is an inefficient use of space and pavement; homes only exist on one side of the road. If the planners' intent was for the homes along this road to face the scenic beauty of the creek and its surroundings, a 25' wide span of pavement did not need to be included. It would have been preferable in this situation not to have included the vehicular thoroughfare. A sidewalk or bike path would have been sufficient for pedestrian circulation. The unhindered view of the adjacent wilderness would not be marred by aimless traffic. Circulation patterns would remain interconnected. Homes would still be accessible by car from the secondary system of lanes in the rear. This layout was successfully used for several homes along the small park in the second site-specific plan; it could have been utilized here as well.

A final issue regarding Vickery's layout and its effects on stormwater management involves the existing topography of the site. Perhaps this steep and rolling terrain is not the ideal place for a relatively impervious development of interconnected roads and buildings. Storage and retention become increasingly more important and simultaneously more difficult as slopes increase. Although the planners of Vickery did follow some existing grades in creating this grid of roads, other areas of the development stand out as potential problem spots. Perspective drawings by DPZ & Co. best illustrate this point. Every perspective represented Vickery as a flat place, with tightly knit buildings that associated well with one another. However, it becomes difficult to recreate these images on the side of a hill.

These points about Vickery perhaps indicate that there are larger lessons for new urbanism to acknowledge as a whole. The new urbanist formula does not respond to the stormwater management challenges it creates. A fundamental component of good design is the ability to respond to such problems; the new urbanist template has yet to do so. The alternative landscape has arguably shown that these built environments and natural processes have potential to function within the same space. Ecological processes do not have to be relinquished to the wild. It has been shown that new urbanist development can accommodate nature in a number of ways, but only to a limited degree.

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APPENDIX A-1

CHARTER OF THE NEW URBANISM: THE REGION*: METROPOLIS, CITY AND TOWN*

1. Metropolitan regions are finite places with geographic boundaries derived from topography,

watersheds, coastlines, farmlands, regional parks, and river basins. The metropolis is made of multiple centers that are cities, towns, and villages, each with its own identifiable center and edges.

2. The metropolitan region is a fundamental economic unit of the contemporary world. Governmental cooperation, public policy, physical planning, and economic strategies must reflect this new reality.

3. The metropolis has a necessary and fragile relationship to its agrarian hinterland and natural landscapes. The relationship is environmental, economic, and cultural. Farmland and nature are as important to the metropolis as the garden is to the house.

4. Development patterns should not blur or eradicate the edges of the metropolis. Infill development within existing urban areas conserves environmental resources, economic investment, and social fabric, while reclaiming marginal and abandoned areas. Metropolitan regions should develop strategies to encourage such infill development over peripheral expansion.

5. Where appropriate, new development contiguous to urban boundaries should be organized as neighborhoods and districts, and be integrated with the existing urban pattern. Noncontiguous development should be organized as towns and villages with their own urban edges, and planned for a jobs/housing balance, not as bedroom suburbs.

6. The development and redevelopment of towns and cities should respect historical patterns, precedents, and boundaries.

7. Cities and towns should bring into proximity a broad spectrum of public and private uses to support a regional economy that benefits people of all incomes. Affordable housing should be distributed throughout the region to match job opportunities and to avoid concentrations of poverty.

8. The physical organization of the region should be supported by a framework of transportation alternatives. Transit, pedestrian, and bicycle systems should maximize access and mobility throughout the region while reducing dependence upon the automobile.

9. Revenues and resources can be shared more cooperatively among the municipalities and centers within regions to avoid destructive competition for tax base and to promote rational coordination of transportation, recreation, public services, housing, and community institutions.

CHARTER OF THE NEW URBANISM: THE NEIGHBORHOOD, THE DISTRICT, AND THE CORRIDOR

10. The neighborhood, the district, and the corridor are the essential elements of development and redevelopment in the metropolis. They form identifiable areas that encourage citizens to take responsibility for their maintenance and evolution.

11. Neighborhoods should be compact, pedestrian-friendly, and mixed-use. Districts generally emphasize a special single use, and should follow the principles of neighborhood design when possible. Corridors are regional connectors of neighborhoods and districts; they range from boulevards and rail lines to rivers and parkways.

12. Many activities of daily living should occur within walking distance, allowing independence to those who do not drive, especially the elderly and the young. Interconnected networks of streets should be designed to encourage walking, reduce the number and length of automobile trips, and conserve energy.

13. Within neighborhoods, a broad range of housing types and price levels can bring people of diverse ages, races, and incomes into daily interaction, strengthening the personal and civic bonds essential to an authentic community.

14. Transit corridors, when properly planned and coordinated, can help organize metropolitan structure and revitalize urban centers. In contrast, highway corridors should not displace investment from existing centers.

16. Appropriate building densities and land uses should be within walking distance of transit stops, permitting public transit to become a viable alternative to the automobile.

17. Concentrations of civic, institutional, and commercial activity should be embedded in neighborhoods and districts, not isolated in remote, single-use complexes. Schools should be sized and located to enable children to walk or bicycle to them.

18. The economic health and harmonious evolution of neighborhoods, districts, and corridors can be improved through graphic urban design codes that serve as predictable guides for change.

19. A range of parks, from tot-lots and village greens to ball fields and community gardens, should be distributed within neighborhoods. Conservation areas and open lands should be used to define and connect different neighborhoods and districts.

CHARTER OF THE NEW URBANISM: THE BLOCK, THE STREET, AND THE BUILDING

20. A primary task of all urban architecture and landscape design is the physical definition of streets and public spaces as places of shared use.

21. Individual architectural projects should be seamlessly linked to their surroundings. This issue transcends style.

22. The revitalization of urban places depends on safety and security. The design of streets and buildings should reinforce safe environments, but not at the expense of accessibility and openness.

23. In the contemporary metropolis, development must adequately accommodate automobiles. It should do so in ways that respect the pedestrian and the form of public space.

24. Streets and squares should be safe, comfortable, and interesting to the pedestrian. Properly configured, they encourage walking and enable neighbors to know each other and protect their communities.

25. Architecture and landscape design should grow from local climate, topography, history, and building practice.

26. Civic buildings and public gathering places require important sites to reinforce community identity and the culture of democracy. They deserve distinctive form, because their role is different from that of other buildings and places that constitute the fabric of the city.

27. All buildings should provide their inhabitants with a clear sense of location, weather and time. Natural methods of heating and cooling can be more resource-efficient than mechanical systems.

28.. Preservation and renewal of historic buildings, districts, and landscapes affirm the continuity and evolution of urban society.

APPENDIX A-2

Table A-1: Determination of Predevelopment Curve Number and S Value with Total Open Space (214.75 Acres)

PREDEVELOPMENT SITE HYDROLOGIC SOIL GROUP B					
	AREA (FT^2)	**ACRES**	**% of total (214.75 acres)**	**CN**	**WEIGHTED CN**
WOODLAND	5,982,010	137	64%	55	35.17
GRASSLAND	3,150,000	72	34%	61	20.54
BUILDINGS	117,000	3	1%	98	1.23
PAVEMENT (GRAVEL)	105,500	2	1%	85	0.96
TOTAL	9,354,510	**214.75**	**100%**		**57.90**

$$CN_{PREDEVELOP} = 57.90$$

$$S_{PREDEVELOP} = \frac{1000}{57.90} - 10$$

$$S_{PREDEVELOP} = 7.27$$

APPENDIX A-3

Table A-2: Determination of Original Plan, Curve Number and S Value with Total Open Space (214.75 Acres)

ORIGINAL MASTER PLAN HYDROLOGIC SOIL GROUP B						
		AREA (FT^2)	ACRES	% of total (214.75 acres)	CN	WEIGHTED CN
THOROUGHFARES						
	TOTAL	1,075,690	24.69	11.50%		
	IMPERVIOUS	859,810	19.74	9.19%	98	9.01
	GRAVEL	215,880	4.96	2.31%	85	1.96
PARKING						
	TOTAL	120,000	2.75	1.28%		
	IMPERVIOUS	120,000	2.75	1.28%	98	1.26
BUILDINGS						
	TOTAL	1,088,775	24.99	11.64%		
	COMMERCIAL	118,000	2.71	1.26%	98	1.24
	RESIDENTIAL	740,225	16.99	7.91%	98	7.75
	GARAGES	230,550	5.29	2.46%	98	2.42
WALKS						
	TOTAL	332,900	7.64	3.56%		
	IMPERVIOUS	332,900	7.64	3.56%	98	3.49
VEGETATED AREAS		3,164,945	72.66	33.83%	69	23.35
OPEN SPACE						
	TOTAL	3,572,200	82.01	38.19%		
	IN DEVELOPMENT ZONE	686,350	15.76	7.34%	61	4.48
	OUTSIDE DEVELOPMENT ZONE	2,885,850	66.25	30.85%	55	16.97
TOTAL		9,354,510	**214.75**	**100%**		**71.91**

$$CN_{ORIGINAL} = 71.91$$

$$S_{ORIGINAL} = \frac{1000}{71.91} - 10$$

$$S_{ORIGINAL} = 3.91$$

APPENDIX A-4

Table A-3: Determination of Alternative Landscape Retention Volume

RETENTION VOLUME OF THE ALTERNATIVE LANDSCAPE			
METHOD	**QUANTITY**	**UNITS**	**TOTAL ft^3**
Storage Chambers	27,739 linear feet	3 ft^3 per l.f.	83,217 ft^3
Storage Bays	3,310 linear feet	5.4 ft^3 per l.f.	17,874 ft^3
On-Street Parking	15,000 linear feet	4.2 ft^3 per l.f.	63,000 ft^3
Central Green	1	1,000 ft^3	1,000 ft^3
Planting Swales			
Roads ≤ 5%	475 swales	50 ft^3 per swale (avg.)	23,750 ft^3
Roads ≥ 6%	475 swales	25 ft^3 per swale (avg.)	11,875 ft^3
TOTAL			**200,716 ft^3**

Table A-4: Determination of Alternative Landscape S Value for Total Open Space (214.75 Acres)

DETERMINATION OF $S_{ALTERNATIVE}$		
Stored (ft^3)	200,716 ft^3	
divided by total area (214.75 acres)	9,354,510 ft^2 [1]	
$S_{ALTERNATIVE}$ =	**0.021 feet** *or* **0.252 inches**	

The following formula is used to calculate $CN_{ALTERNATIVE}$ using calculated S values for the original and alternative landscapes for the 214.75 acre total site (Tables A-1 and A-2):

Table A-5: Determination of Alternative Landscape Curve Number for Total Open Space (214.75 Acres)

$$CN_{ALTERNATIVE} = \frac{1000}{(S_{ORIGINAL} + S_{ALTERNATIVE} + 10)}$$

$$CN_{ALTERNATIVE} = \frac{1000}{(3.91 + .252 + 10)} \quad \textit{therefore,} \quad CN_{ALTERNATIVE} = 70.61$$

APPENDIX A-5

LIST OF RECOMMENDED PLANTS

SCIENTIFIC NAME	COMMON NAME
TREES	
Amelanchier arborea	Serviceberry
Acer rubrum	Autumn Flame Red Maple
Aesculus pavia	Red Buckeye
Betula nigra	River Birch
Carpinus caroliniana	Musclewood
Cercis canadensis	Eastern Redbud
Chionanthus virginicus	American Fringetree
Cornus florida	Dogwood
Ilex opaca	American Holly
Ilex verticillata	Winterberry Holly
Juniperus virginiana	Eastern Red Cedar
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Tulip Poplar
Myrica cerifera	Wax Myrtle
Magnolia grandiflora	Southern Magnolia
Magnolia virginiana	Sweet Bay Magnolia
Nyssa sylvatica	Blackgum
Oxydendrum arboreum	Sourwood
Pinus echinata	Shortleaf Pine
Pinus taeda	Loblolly Pine
Pinus virginiana	Virginia Pine
Platanus occidentalis	Sycamore
Quercus alba	White Oak
Quercus coccinea	Scarlet Oak
Quercus nigra	Water Oak
Quercus shumardii	Shumard Oak
Taxodium distichum	Bald Cypress
Ulmus alata	Winged Elm

SCIENTIFIC NAME	COMMON NAME
SHRUBS	
Aesculus parviflora	Buckeye
Clethra alnifolia	Clethra
Callicarpa americana	Beautyberry
Calycanthus floridus	Sweetshrub
Fothergilla x 'Mt Airy'	Mt. Airy Fothergilla
Fothergilla major	Large Fothergilla
Hydrangea quercifolia	Oakleaf Hydrangea
Ilex glabra	Inkberry Holly
Illicium floridanum	Florida Anise
Itea virginica	Virginia Sweestpire
Kalmia latifolia	Mountain Laurel
Myrica cerifera var. pumila	Dwf. Wax Myrtle
Prunus caroliniana	Carolina Cherrylaurel
Rhododendron canescens	Piedmont Azalea

SCIENTIFIC NAME	COMMON NAME
GROUNDCOVERS and PERENNIALS	
Asclepias tuberosa	Butterfly Weed
Athyrium filix-femina	Southern Lady Fern
Andropogon virginicus	Broomsedge
Andropogon glomeratus	Bushy Bluestem
Amsonia tabernaemontana	Blue Star
Amsonia hubrectii	Arkansas Blue Star
Chasmanthium latifolium	Northern Sea Oats
Dryopteris marginalis	Southern Shield Fern
Digitalis purpurea	Foxglove
Eupatorium fistulosum	JoePye Weed
Echinacea purpurea	Purple Coneflower
Gelsemium sempervirens	Carolina Jessamine
Helianthus angustifolius	Swamp Sunflower
Iris fulva	Copper Iris
Lonicera sempervirens	Honeysuckle
Monarda didyma	Bee Balm
Osmunda cinnamomea	Cinnamon Fern
Osmunda regalis	Royal Fern
Panicum virgatum 'Shenandoah'	Shenandoah Switchgrass
Polystichum acrostichoides	Christmas Fern
Solidago 'Fireworks'	Fireworks Goldenrod
Stokesia laevis	Stokes Aster
Trachelospermum jasminoides	Star Jasmine
Thelypteris kunthii	Southern Wood Fern
Vernonia angustifolia	Iron Weed

APPENDIX A-6

PRODUCT SPECIFICATIONS

SF Rima™

CAN Tech

SF Rima™ pavers are an innovative and environmental system designed to reduce or eliminate storm water runoff, decrease flooding and relieve sewer systems. They are also ideal as a turf pavement, which allows for irrigation and cooling of surfaces. SF Rima pavers are made under extreme pressure and high-frequency vibrations, and have a compressive strength greater than 8,000 psi and a water absorption maximum of 5%. With their interlocking joints, they can support heavy vehicular loads.

SF Rima pavers are perfect for:

- Driveways
- Parking lots
- Gas stations
- Bridge abutments
- Crosswalks
- Street medians
- Intersections
- Industrial plants
- Industrial yards
- Factory streets
- Highway ramps
- Bridge underpasses
- Bus terminals
- Industrial/Commercial ports

3 1/8" x 7 3/4" x 7 3/4"
8 cm x 19 cm x 19 cm

Product Data*

For Water Drainage

Coverage	Units per Pallet	Coverage per Pallet	Weight per Piece	Weight per Pallet
2.12 pcs/ft^2 (22.8 pcs / m^2) with ½" joint (13mm)	160	75.5 ft^2 (7.01 m^2)	16.31 lbs (7.4 kg)	2,660 lbs (1,207 kg)

For Turf Growth

Coverage	Units per Pallet	Coverage per Pallet	Weight per Piece	Weight per Pallet
1.88 ft^2 (20.4 pcs / m^2) with 1" joint (25mm)	160	85.1 ft^2 (7.84 m^2)	16.31 lbs (7.4 kg)	2,660 lbs (1,207 kg)

All ***Weight per Pallet*** noted above include a 50 lb pallet weight.

** All metric dimensions are soft converted to Imperial.*

SF Rima is sold by the piece.

Standard Specification

Meets or exceeds CAN CSA: A 231.2
SF Rima is manufactured to Mutual Materials standard specifications, as well as ASTM: C 936.

Available Colours

For a complete list of available colours, see Mutual Materials stocking products list. For more information regarding custom colours, please contact a sales representative. Custom colours may be restricted by the size of the order or project.

Uni-Ecoloc®

Uni-Ecoloc is an environmentally beneficial heavy-duty paving system designed to reduce stormwater runoff on industrial and commercial pavements.

Uni-Ecoloc is a L-shaped interlocking concrete paver and part of the Uni-Anchorlock family of pavers. Ecoloc pavers provide a highly durable, yet permeable pavement capable for supporting the highest vehicle loads. When installed, the unique patented design creates drainage openings in the pavement's surface, which facilitate rainwater infiltration like the Eco-Stone® system. Uni-Ecoloc is a mechanically installed product.

Ecoloc pavers are perfect for municipal, commercial and industrial applications, including:

- Industrial plants
- Industrial ports
- Storage depots
- Industrial parks
- Military installations
- Factory yards & streets
- Loading docks
- Container and bus terminals
- Airport taxiways, Maintenance and Hangar areas

8 cm x 22.5 cm x 22.5 cm
3 1/8" x 8 7/8" x 8 7/8"

Product Data*

Coverage per Layer	Layers per Pallet	Coverage per Pallet	Weight per Layer	Weight per Pallet
11.35 ft² (1.055 m²)	8	8.44 m² (90.8 ft²)	315 lbs.	2,570 lbs.

All ***Weight per Pallet*** noted above include a 50 lb pallet weight.

** All metric dimensions are soft converted to Imperial. Dimensions and coverage include 1.5 mm (1/16") joint.*

Uni-Ecoloc must be purchased by the full layer or full pallet.

Standard Specification

Uni-Ecoloc pavers are manufactured to Mutual Materials standard specifications as well as ASTM: C 936.

Available Colors

For a complete list of available colors, see Mutual Materials stocking products list. For more information regarding custom colors, please contact a sales representative. Custom colors may be restricted by the size of the order or project.

Pallet Layout

Uni-Ecoloc pavers are designed to be mechanically installed a full layer at a time. Layers are off-set to create a strong, interlocking pavement surface.